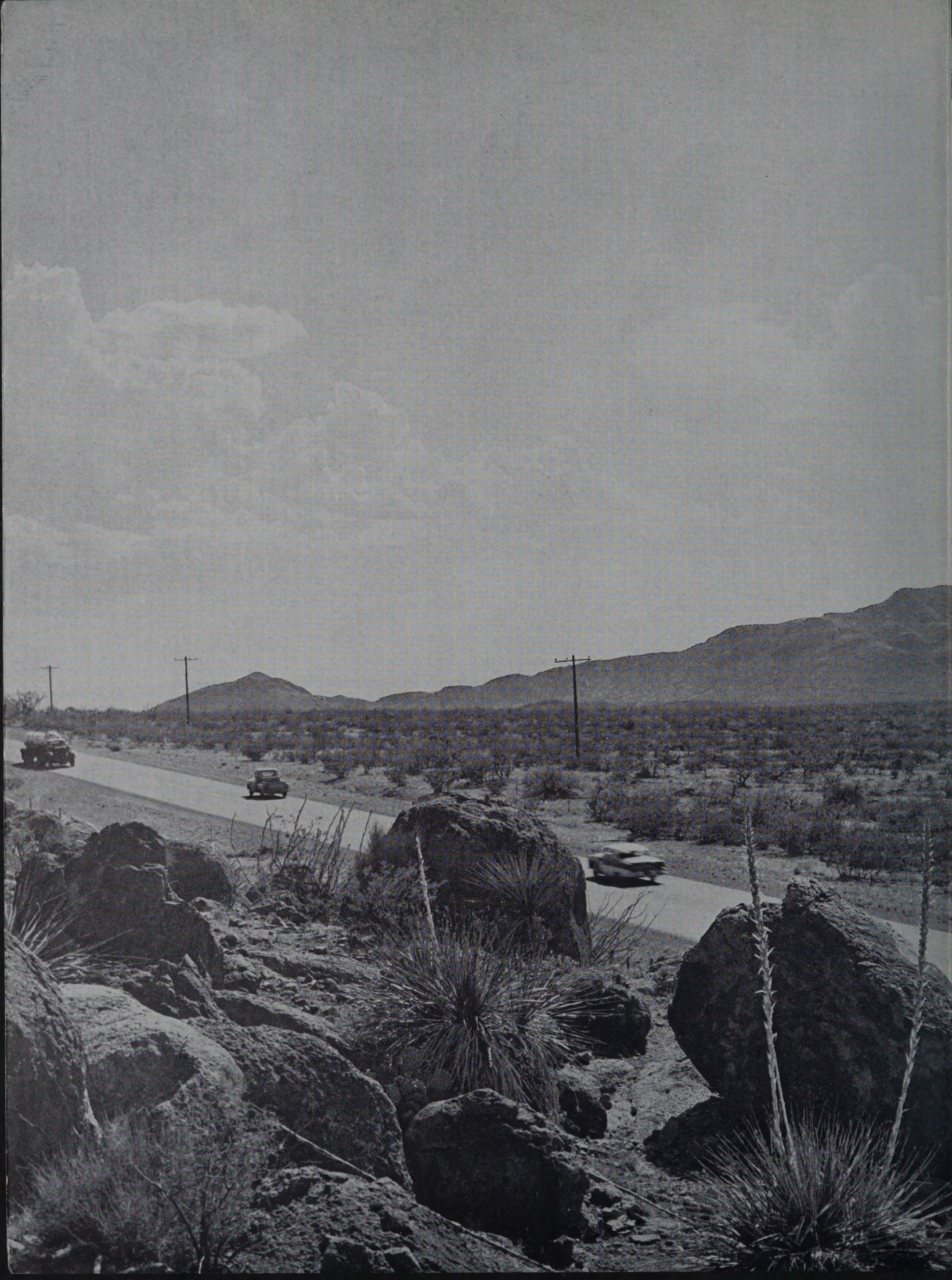
Texas Highways

July, 1960 35c



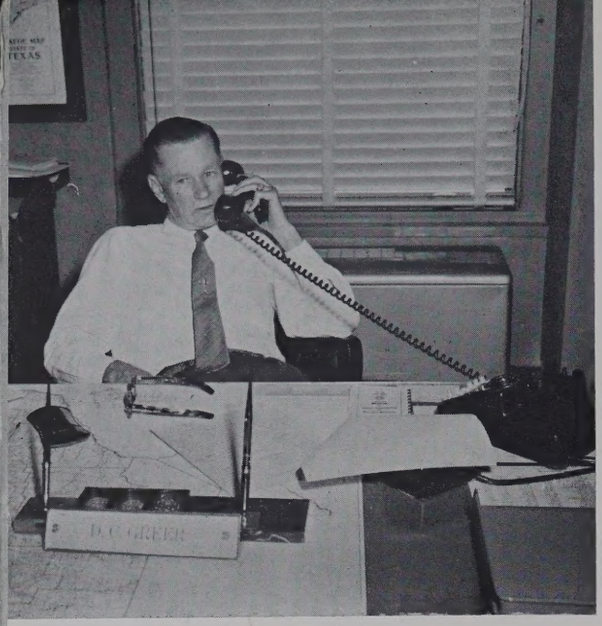
Texas Highways

Volume 7 • Number 7

July, 1960

Contents

A Tribute	2
Black Widow Business	5
In the Public Eye	10
Research in Asphalt Quality Control	12
Harvey Deen	16
Preventive Maintenance	20
Epoxy Resins in Concrete Construction and Maintenance	22
First-Aid Training	29
Operation Bulldozer	30
Over the Highways	31



A Tribute

D. C. Greer, State Highway Engineer . . .

This month TEXAS HIGHWAYS salutes a man who has been at the helm of the Texas Highway Department for twenty years. In this capacity, Dewitt C. Greer has made Texas a leader in highway development.

These twenty years have been vital ones in highway building. Under Greer's leadership, paved mileage in Texas has more than tripled—from 17,400 miles to a designated 61,137 miles today.

After graduation in civil engineering from Texas A & M College in 1923, Greer worked in various phases of construction and engineering until his initial employment by the Highway Department in 1927 as Assistant Resident Engineer in Henderson County. Later he became District Engineer for District 10, and in 1936 transferred to Administration in Austin as Chief Engineer of Construction and Design. And on July 1, 1940, he was named State Highway Engineer.

Greer has become legend in his own time. His twenty-year tenure in the top post is more than double that of any previous State Highway Engineer. Gibb Gilchrist seconds the record with nine years' service.

A man of vision and integrity, Greer commands the respect of all who know and work with him. His reign has been one of harmony and accomplishment; a period of expansion and development unsurpassed in history. Texas leads the nation in progress on the Interstate Highway program, with 436.2 miles of multilane divided highway completed; 273 under construction; and 499.4 miles

. . . newly appointed, meets with his district engineers for the first time in Austin on November 25, 1940. Left to right, first row, are Greer, John B. Nabers, J. W. Puckett, E. C. Woodward, S. C. McCarty, S. J. Treadaway, J. G. Lott, George M. Garrett, T. W. Bailey, and A. C. Gentry. On the second row are Leo Ehlinger, J. G. Rollins, J. M. Isbell, John E. Blair, P. S. Bailey, J. E. Pirie, George B. Finley, R. E. Killmer, Clifton Rice, and T. J. Kelly. Top, back, are D. M. Puckett, M. C. Welborn, F. S. Maddox, and A. F. Moursund.

. . . aboard the ferry at the Galveston Ferry Christening in 1950. Left to right are J. M. Page of the Bureau of Public Roads, Commissioner A. F. Mitchell, District Engineer Jim Douglas, and Greer.

. . . receives his 30-year award in September of 1957 from Commissioners Marshall Formby, Herb Petry, and Charles F. Hawn.

of existing multilane divided highway which require additional work to bring them up to Interstate standard.

Giant projects have been undertaken, completed, and added to the State Highway System in these past twenty years. The Gulf Freeway, opened to the public in 1952, cut driving time on the 50-mile stretch between Galveston and Houston in half.

The Baytown Tunnel was completed in 1953 and is the only tunnel on the highway system. The Pecos High Bridge, finished in 1957, carries traffic a safe 273 feet above the erratic Pecos River. The first four-level interchange made its appearance on Texas highways in 1958, in Fort Worth. The Corpus Christi Harbor Bridge, spanning the ship channel, eliminated in 1959 the long-existant bottleneck caused when ships entered the harbor.

Greer's accomplishments have not been limited to Texas, but spread the width of the nation and abroad. He is a member of the American Society of Civil Engineers and Tau Beta Pi, honorary engineering fraternity. He is a past president of the American Association of State Highway Officials and is now on the executive committee of that association. In 1953 he received the George S. Bartlett Award for outstanding contributions to high-

. . . at a Highway Commission Hearing, along with Hawn, Chairman Formby, and Petry, in August of 1958.

. . . attends the Pecos River High Bridge Opening in April of 1957. With him are Commission Chairman Eli Thornton and Member Herb Petry.

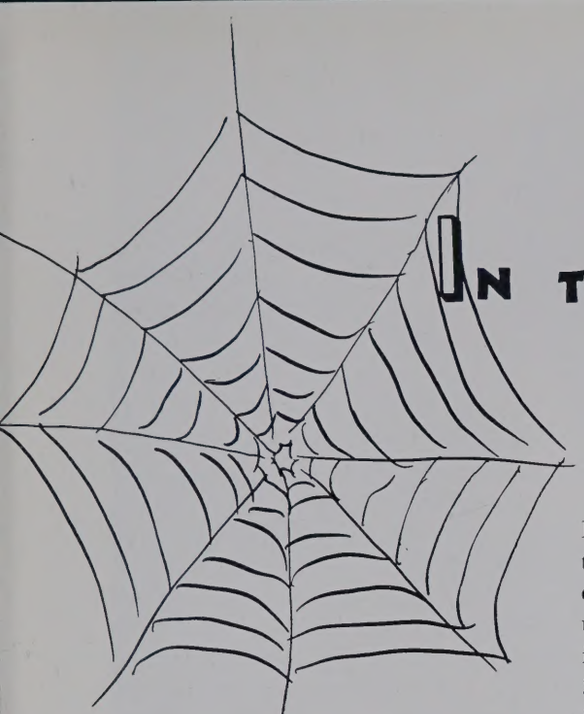
way progress. This award is recognized as the highest honor that may be conferred on the present-day highway builder.

In 1954 he made a lecture tour of Europe at the invitation of the International Road Federation. He was selected for the assignment because of the "leadership Texas has shown in highway construction, operation, and financing."

In 1958, Greer was named to the advisory council of the Yale University Bureau of Highway Traffic. This school is widely known as the outstanding school of its type in the nation, and enlists the counsel and skill of leaders in the highway field.

Never one to take credit, Greer always attributes progress on Texas highways to employees of the Department and citizens of Texas. So—for having earned the continuing respect and cooperation of employees and citizens over the years, TEXAS HIGHWAYS pays tribute to D. C. Greer.

. . . at the 1948 Short Course with division heads and district engineers. Identified numerically, they are, 1) V. G. Koch, 2) Ed Bluestein, 3) R. J. Hank, 4) John B. Nabers, 5) A. C. Gentry, 6) J. F. Snyder, 7) D. T. Harkrider, 8) Frank Maddox, 9) Tom Davis, 10) A. F. Moursund, 11) T. H. Webb, 12) J. W. Puckett, 13) Leo Ehlinger, 14) Jim Douglas, 15) George Edwards, 16) Jed Robinson, 17) B. B. Freeborough, 18) Greer, 19) J. P. Exum, 20) R. E. Killmer, and 21) Tom Collier. Next, 22) George Finley, 23) T. J. Kelly, 24) Guy Lott, 25) Herbert Eldridge, 26) E. J. Amey, 27) S. J. Treadaway, 28) L. A. Fletcher, 29) Percy Bailey, 30) S. J. McCarty, 31) Ray Faltinson, 32) John Waller, 33) John Blair, 34) W. D. Dockery, 35) George Pendergrass, 36) Fred T. Bennett, 37) J. M. Isbell, 38) M. C. Welborn, 39) M. B. Hodges, 40) George Garrett, 41) F. M. Davis, 42) Harvey Deen, and 43) D. M. Puckett.



IN THE INSTRUMENT REPAIR SHOP...

Black Widow Business

At last count, the Texas Highway Department owned 2,200 levels and transits. One of the transits is a veteran which has figured in road measurements taken by highway engineers in the South High Plains for the past 30 years. In the Wichita Falls District is a 35-year-old level which was assigned there when no longer needed by District 14, where it had been used for thirteen years.

Once a surveying instrument is bought by the Department—and on today's market the conventional transit costs $494, the level at least $225—it begins a service march which will stretch an indefinite number of years into the future. Its longevity will depend in measure on tender, loving care and in measure on how well its users remember that cardinal surveying rule, "Never leave your instrument unattended."

The Department itself cleans and repairs this expensive equipment. A seven-man section attached to Equipment and Procurement Division at Camp Hubbard in Austin is responsible. Claude C. Evans, Chief Instrument Repairman, says that, ideally, a transit and level will be sent in for checkup and cleaning once a year. Such user solicitude, however, is not usually the rule. The record card on one 35-year-old level, for instance, indicates it has been sent back no more than twice for repairs. "Instruments this old are frequently delivered to us with the request, 'repair and return,' so we know they are still in use," Evans said.

The three men on Evans' staff who disassemble and reconstruct the instruments must spend two, or maybe three, days cleaning the very neglected ones. And when they tackle a transit or level which has taken some knocks, a longer time is required. Ten-day service is the aim of repairmen, taking the work in the order in which it arrives.

Transit or theodolite parts, larger but almost as numerous as those of a pocket watch, may be spread out before Eddie Goertz, Milton Sweet, or Robert Price. Like jewelers, these men work in separate, well-lighted booths, especially designed and located in the new Equipment and Procurement Building. First by intuitive knack, then by practice, these men have learned the construction differences of ten trade brands of transits, levels, and theodolites which the Department has purchased through the years.

While appreciative of the fine craftsmanship in the conventional models which predominate in the Department, these repairmen express admiration for the newest type surveying instrument which they now service. These are small double-circle, direct reading, triangulation theodolites, the first five of which were bought by the Department at the request of Bridge Division engineers working on construction of special jobs. There are now 75 sets of these theodolites with their companion optical reading levels in use throughout the districts, Evans estimates. Explaining the differences between this four-pound instrument and the conventional transit, Evans said that rod and level bubbles are made at the same reading with the levels. "When you turn an angle with this double circle theodolite, the reading is accurate, while with conventional transits the surveyor must make several readings and obtain an average," Evans stated.

There is usually a black widow spider on call in a bottle near the workbenches. The silk produced by a me-

dium-sized black widow makes the most perfect cross hair inside the reticle of any optical instrument. Spun glass, steel and platinum wire, nickel alloy wires, and nylon are sometimes used in optical reticules, but spider filament is still considered the strongest, the finest, the most elastic. It is the replacement cross-hair material used at Camp Hubbard.

The men who repair Highway Department surveying instruments explain that black widow silk is very even in diameter and is tougher than steel or platinum wire of the same diameter. In the early 1900's Keuffel and Esser, instrument-manufacturing name familiar to most engineers, was taking dragline threads from living spiders for use in surveying instruments. During World War II there was great demand for it as cross hairs in telescopic sights, rifle sights, and range finders. Today spider silk is found not only in surveying transits and levels but also in astronomical telescopes, microscopes, and medical instruments. The single strand spun by a spider traveling up and down in the air is the only type of silk which can be used for instruments. Web silk, for snaring prey, is sticky and not usable.

A black widow spider in her glass bottle cage requires little care. Kept supplied with an occasional fly and two or three drops of water per week, she will easily give at one silking what would cost the Highway Department $100 if bought retail. The men at Camp Hubbard recall one black widow who was their co-worker for six months. This sets a record. They cite her as the best producer in their memory. But it was her energetic production of thousands of baby spiders, found teeming in the bottle one morning, which severed the partnership. So diminutive were her progeny, they could escape through air holes punched in the lid of the bottle. The men at Camp Hubbard felt this created an occupational hazard.

Though spider replacements are usually easy to find in overturned cans or buckets out along a fence row, one time during a siege of cold, wet weather in Austin the Camp Hubbard repairmen could find no black widow in the usual haunts. This necessitated the purchase of spider silk from a commercial firm. Fifty feet of silk (1,500 cm.) cost the Department $15. Commercially, spider silk is advertised in diameters from extra-fine (1/50,000 of an inch) to extra-heavy (1/5,000 of an inch).

At Camp Hubbard there is a stockpile of junked transits with which destiny has dealt none too kindly. From these the instrument repairmen remove usable parts. The tragic end of much of this equipment came because of a surveyor's forgetfulness of the maxim: "Never leave your instrument."

There was, for instance, the field party which left a transit and tripod in a pasture for a short while. Upon their return, they could find their instrument nowhere. Next day, while

A transit equals the total of all its parts. Eddie Goertz, Senior Instrument Repairman, has before him a typical job, a completely disassembled transit which will be immersed in cleaning solution, refinished if the paint is bad, then refitted. At least two adjustments are required for the instrument to "settle down" after all the screws have been removed and replaced.

Not from books but from a tutor is E. C. Olle (left), Instrument Repairman, learning to service transits, levels, theodolites, alidades, planimeters, dial gauges, and mechanical drafting machines which the Instrument Repair Shop keeps in running condition for the Department. Goertz explains the intricacies of the level vials and the telescope on this transit model.

the Department surveyors were sitting at coffee in a drugstore of the small town nearby, they overheard a farmer telling local friends that one of his cows had come in for milking the previous evening with a "telescope" hooked over her neck.

Another surveying party, taking reading near a high school found it necessary to set one leg of a tripod over a sidewalk curb. The transit was left unattended for a matter of minutes, during which time a covey of high schoolers came walking along, four abreast. The one who found the tripod in his path kicked it a-winding. To repair the damages: About $175 in parts.

Perhaps the most incredible story told by a Department surveying crew involves the demise of a transit which was set up in the center of a highway. The crew looked up as a car came zooming along astraddle the center stripe. Scrambling to personal safety, the instrumentman deserted the transit, which was duly mowed down by the automobile. The surveyors jumped in their own conveyance and followed the culprit, who stayed accurately in the middle of the road all the way to the next town. Enlisting the authority of the local sheriff, the Department men approached the driver who, by then, was shopping in one of the stores along the town square. He listened while they heatedly made their charges about his ruining their equipment. Then he said, "Is *that* what was on the road back yonder? I *thought* I hit something." As it was soon discovered, the man was nearly blind and had found he could stay on the road only if he followed the center stripe.

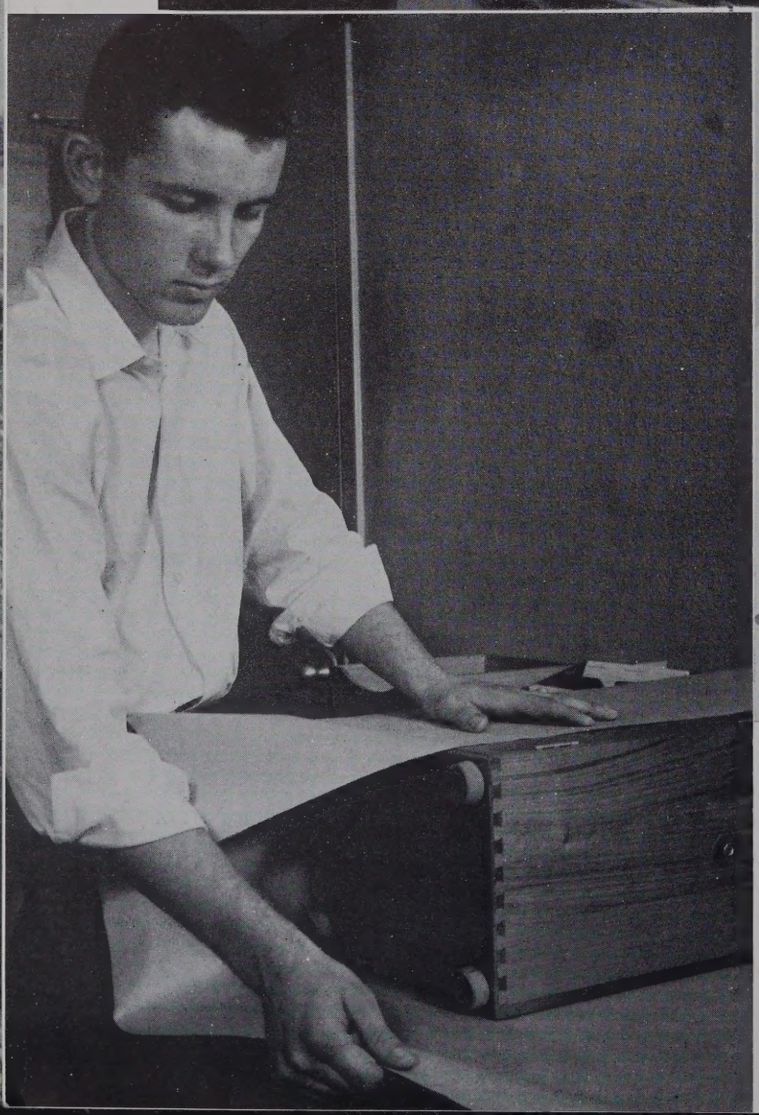
Orders are sent from the districts directly to Equipment and Procurement Division in Austin when new levels and transits are needed. At that time registration cards are made in the Instrument Repair Shop. Evans pointed to the new cards filed among those of other years and observed that the interstate program has accelerated the request for new surveying equipment. As the count now stands, Corpus Christi and Beaumont districts have the greatest number of registration cards in the file.

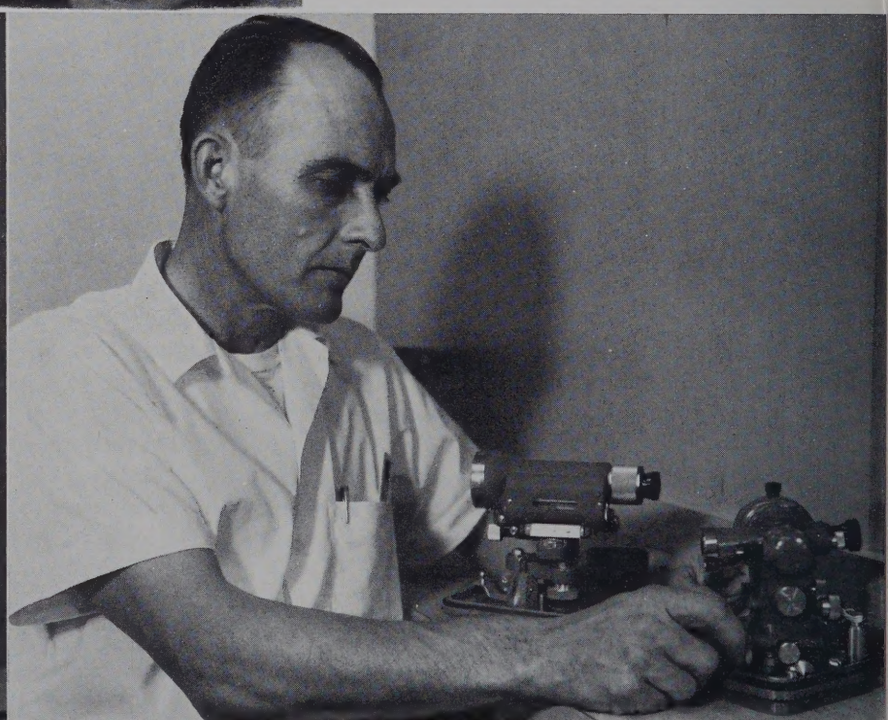
The only charge for repairs or checkups of these costly engineering necessities is the transportation fee both ways. Sent to Austin prepaid, they are returned collect. Some arrive packed very casually, a fact which makes the repairmen flinch, thinking of the jolts and consequential damage an instrument can receive en route. A thorough job of crating is performed at the Austin end of the line when repairs have been completed, and a printed card giving the correct address of the repair shop is pasted in the carrying case. Transits and levels in need of first aid or major repairs come addressed in varying ways. Some even make a roundabout trip because they are addressed to the Main Office. Of course, these must then be rerouted out to Camp Hubbard.

The ten-day service which the repair shop strives for can be assured for a transit or level which has fallen or has had some real mishap only if a letter notifying the shop accompanies the instrument. "This calls to our attention that more than cleaning and checkup is needed. We can make an immediate inspection and order the parts which may be necessary," Chief Evans said. He said further that as much as 30 days are required to receive special parts from some manufacturers.

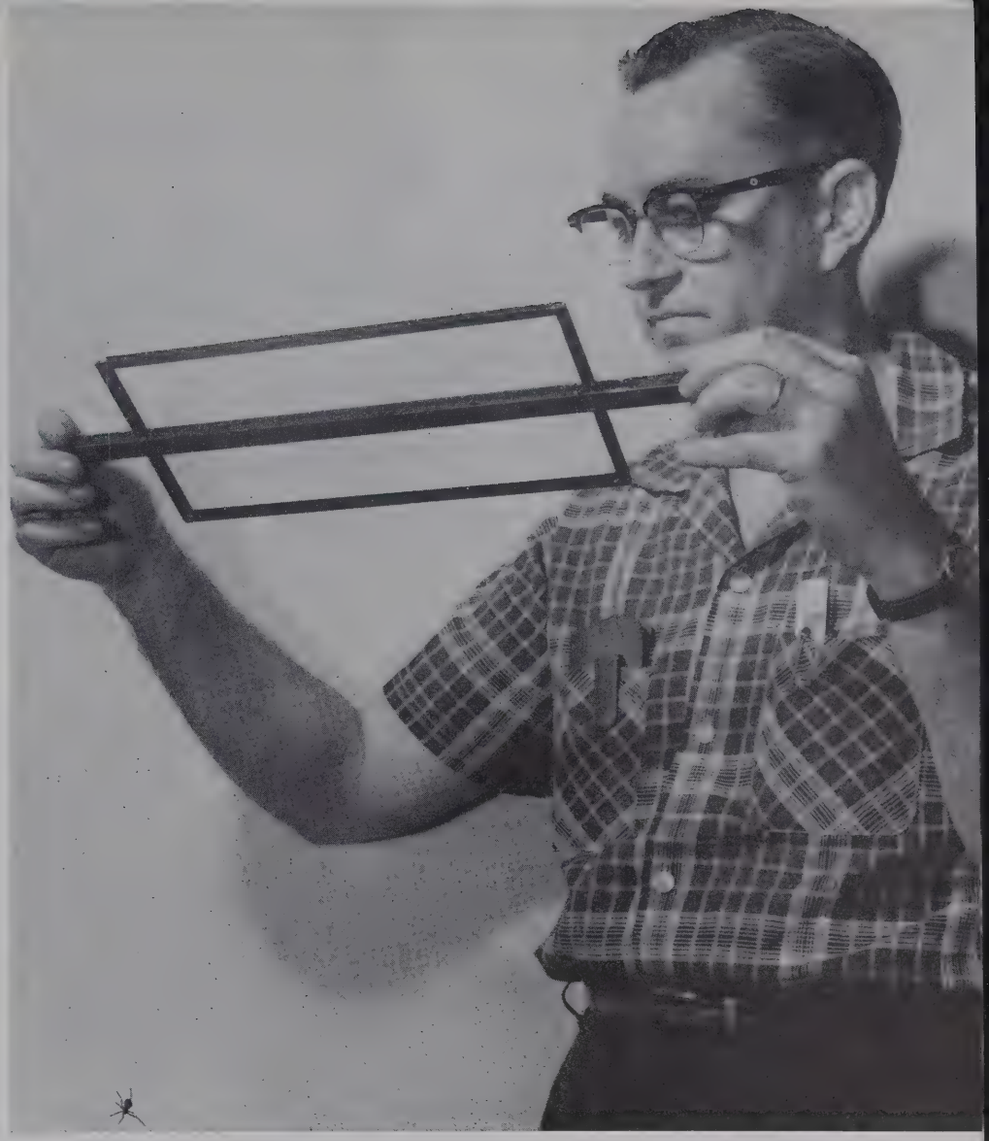
"What can you do about a wreck like this?" Chief Instrument Repairman Claude Evans seems to think, as he surveys a transit which was left unattended in the vicinity of a bulldozer. Transits and levels which have been through harsh experiences like this are kept in a parts boneyard where the repairmen occasionally find something they need.

A new challenge to the men who take care of the thousands of transits and levels owned by the Department is this four-pound theodolite and level. Robert Price, Senior Instrument Repairman, checks a set which has been ordered by a district.





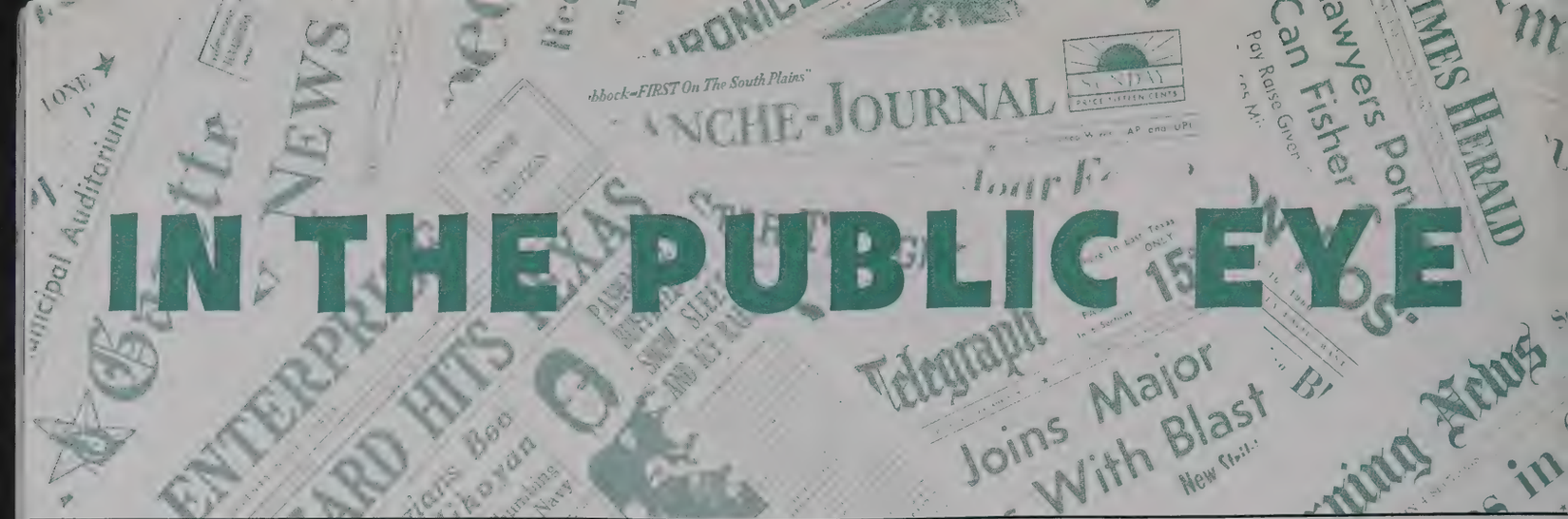
Back to the district goes a shipshape instrument. Eldon Tarver, Semi-Skilled Laborer, wraps a carrying case containing one of the newer transits, will send it via freight, collect. Older instruments and many sent to the shop in flimsy containers require special crating on the Austin end of the line.



Black widow spider silk, which Milton Sweet, Senior Instrument Repairman, is winding on this frame while Madame Spider spins, will provide cross hairs for telescopes. A spider will spin about 100 feet of dragline silk at one silking. Tensile strength of this natural product is greater than steel.

How to Ruin A Transit

1. Natural wear is abuse if it is allowed to go long enough to gather excess dirt thereby increasing the rapidity of wear.
2. Continuous use of a transit after a grain of sand has found its way to, and lodged between, the vernier and limb. This is a $60 factory regraduating job.
3. The use of sewing machine oil which dries rapidly, but not before it has gathered dust which adheres to the clamps and spindles forming an abrasive that "grinds out" the accuracy of the instrument.
4. Excess tightening and uneven tightening of screws. This puts back into the instrument some of the stresses that the manufacturer spent so much time taking out by heat treating. These stresses cause the instrument to "crawl" with the changes in temperature.
5. Using the instrument without sun shade or allowing the sun to shine directly into the objective lens. This causes the balsam separating the crown and flint glasses to deteriorate.
6. Using excess pressure when wiping dust off the lenses or the use of hard or coarse cloth or paper for the purpose. A camel's hair brush or one similar should be used.
7. Thrusting or plunging the tripod leg points into the ground while instrument is attached.
8. Improper carrying of instrument while attached to tripod.
9. Forcing the tangent screws and leveling screws when they are clogged with sand.
10. Not protecting the instrument while it is being hauled over rough road or terrain.
11. Riding in car or truck with one's feet resting on instrument box.
12. Using hammer and chisel to unscrew instrument from tripod.
13. Using graphite of any kind for lubricant.
14. Allowing instrument to get wet and not drying it at once.
15. Locating an instrument and leaving it unattended:
    a. In high wind.
    b. Among many workmen.
    c. Where pedestrians or vehicles are passing.
    d. In pastures or highways where cattle or other animals are free to roam.



PRESSING FACTS

Houston Press, revealing Commission Chairman H. C. Petry Jr.'s admonition that the $4,313,000,000 Departmental spending program projected for the next ten years wasn't enough—"'. . . this will meet bare needs only,' said Petry at a special luncheon meeting of the Houston Chamber of Commerce Highway Committee.

"With the growth of the state and development of tourism, road needs would grow beyond the minimum program the department has prepared for the Legislature."

GOOD NEWS

Dallas Morning News, announcing that construction of the Gregg County portion of Interstate 20 will take about three years—"The highway will be 16.9 miles long in the county and will have seven interchanges and four grade separations, or overpasses. The highway will require a minimum right of way of 300 feet, have two 24-foot lanes with a 44-foot division between lanes, and have paved shoulders."

San Antonio News, explaining editorially why voters should approve acquisition of the Guadalupe Street Underpass, which is "needed to complete access facilities to the heavily populated West Side—San Antonians must provide necessary rights of way; the State of Texas will build the roads, and with expressways already under construction or authorized, this city will be the first major city in Texas to complete its basic plan."

SHADES OF AUTOMATION

Fort Worth Star-Telegram, explaining the presence of mule teams along the Turnpike—"They weren't around merely to convince Eastern tourists that Fort Worth is really where the West begins.

"Actually, the mules were called in at the recommendation of highway engineers who studied various methods of mowing the toll road's steep slopes.

"The engineers had first tried the tractor method but the tractors slid down the grassy banks endangering the lives of the drivers. . .

" 'This was also dangerous,' said J. E. Stephens, superintendent of maintenance for the turnpike. . . . 'Expensive, too. . . .'

"Finally, the mule teams were called in. They had no trouble at all keeping their balance.

" 'People stopped and talked to us all the time—most of them acted like they'd never seen a mule,' said [H. C.] Clark [one of the two team drivers]."

HIGHWAY ON THE HIGH SEAS

Valley Morning Star, carrying a UPI feature about Texas Highway employee Captain J. L. Hughes, "one of eight skippers who ferry motorists across Galveston Bay to Port Bolivar Strait day and night throughout the year.

"The three-mile stretch is the only sea-going stretch of the vast state highway system in Texas.

"Aside from suicide attempts, Hughes said the weather gives him more trouble than anything else. Fog is the weather's worst element for a sea captain.

" 'All in all, I think we've got a pretty good record,' he added. 'Less people get killed per mile on our stretch than on any other. . . .' "

A TAXING SITUATION

San Antonio Light, editorially taking issue with automotive economists who warn that the small cars and their lower gas consumption will seriously cut into tax revenues—"It isn't the small car that's at fault. It is, instead, steadily mounting gasoline taxes that have forced motorists to look for a way to ease their heavy bite.

"It's an example of the old truth that the power to tax is the power to destroy—or distort!"

San Angelo Standard-Times, editorially, about tax rates and little cars—"Now the Highway Transportation Congress, which met in Washington, reports that the growing popularity of the compact cars will pare more than half a billion dollars from gasoline tax receipts of state and federal governments by 1964, and thus imperil the whole ambitious new highway program."

Amarillo Daily News, editorially—"The nation's approach to highway financing is 'far from constructive' in many respects, a widely-known economist charges.

"Robert Heilbroner, writing in Petroleum Today said that on one hand government tends to restrict highway construction to those funds raised by highway taxes and tolls even though the road network brings vast economic benefits to non-motorists as well.

". . . to some extent the country uses its highway traffic as a means of generating general fund revenue. Yet it fails to view the highway system itself as a general national asset on which non-highway revenues may legitimately be expended."

Austin American, editorializing on traffic congestion and federal-state spending—"The federal and state governments spend enormous sums for the massive cloverleafs and 'interchanges' serving through traffic. But in the cities, the basic demand to meet problems of the most serious traffic congestion is for the same people whose gasoline taxes pay the cost of the major highway system . . . to bond themselves and tax their homes to build the necessary streets.

"Traffic is traffic, wherever it rolls, and its most acute problems of urban congestion have not been met by the basic method of highway financing. . . ."

TOURISM AND TANKS

Houston Post, editorially—"The first concrete steps toward removing the light of Texas' tourist attractions from under the bushel and proclaiming them to the nation are about to be taken. First, the State Highway Department is having 200,000 or more copies of a handsome, profusely illustrated brochure in color printed for distribution. . . ."

Dallas Times Herald, quoting from Governor Price Daniel's speech to those attending the Texas Service Station Association's state convention in Austin—". . . the men who 'fill 'er up' are in a strategic position to make visitors feel welcome and appreciated . . . and to mention points of interest."

KEEPING POSTED

Houston Post, datelined Austin—"San Jacinto State Park will soon have the historic date of Texas independence—1836—incorporated into its road signs. Park Road 1836 was ordered marked in Texas Highway Commission action . . . and approximately 6.5 miles of roadway will soon bear the new signs."

Houston Post, discussing widening of the Gulf Freeway between Houston and Galveston, quoted W. E. Carmichael, District 12's Engineer—"Carmichael said the first widening project on the 30 miles of four-lane highway 'will likely be included in the work program this fall.'

"Depending on the financial situation, Carmichael said, the freeway's six-lane system should be completed in 'about six years.' "

Houston Post, reporting progress of Lavaca Bay Causeway project—"With the plaguing northers and extremely low tides just memories of winter, construction work . . . has gone into high gear and a tentative completion date of June, 1960, has been set.

" 'We're three months behind schedule, but that's not too bad off,' Highway Department resident engineer W. A. King of Victoria said. . . .

"Workers are going full-steam, with two shifts driving pilings daily and the casting yard working round-the-clock, King said.

"Engineer King also reported that the Highway 35 Port Lavaca By-Pass Route should be completed within six weeks, barring bad weather."

A MISSING LINK

Houston Post, announcing channel, bridge fete in Matagorda County June 12—"Ceremonies at the [Farm Road 521 lift span] bridge will see ground officially broken on the Colorado River Feeder Channel to the Gulf Intracoastal Waterway. The channel will make Bay City a port on the Intracoastal Canal thus linking it to the great inland waterways system of the nation.

"The Sunday ceremonies . . . will also see the dedication of the bascule-type lift span across the Colorado. The bridge replaces an older structure which will be removed within the next several months. Special guests from the State Highway Department will be honored."

AN ENTERPRISING INDUSTRY

Seguin Enterprise, in a feature headlined "Highway Department Warehouse Good for Seguin" wrote, "A Seguin industry seldom thought of as such observed open house last week and surprised many visitors by the variety and scope of its activities.

"The Texas Highway Department's new offices and warehouse . . . serve not only Guadalupe County, but store and distribute maintenance supplies to nine highway districts."

THE HUMAN ELEMENT

Dallas Morning News, showing survey results of the how's, why's, and wherefore's of traffic violations—"Regardless of how alert you may be, you probably commit as many as three or four violations a day. Maybe a dozen.

"In spite of the confusion in the cities, the greatest number of violations occur on state highways where posted warnings appear to have lost their impact.

"Take, for example, the speed limits. . . .

"Said Traffic Court Judge Herman W. Mead of Houston, addressing a traffic conference in Austin: '. . . to guide the human element in our traffic control problem we must provide the individual driver with sensible, reasonable regulations that can be enforced quickly and efficiently.' "

Dallas Morning News, on cutting down Texas highway fatalities—"D. C. Greer, State Highway Engineer, says improved divided highways are an important factor in cutting down the accident toll. The present 3,000 miles of controlled-access interstate highway in Texas, he reports, are three times safer than ordinary highways. He estimates that this improved type of construction saves one life each ten miles, or 300 lives annually."

The **Austin American,** in a front-page feature about peril along the turnpike—"We're having a hard time adjusting our driving from crowded city streets to the 'safety' of controlled access highways.

" 'Accustomed to the automatic responses in 20 to 40-mph stop-start traffic, most motorists fail to adjust quickly to 70-mph expressway speeds,' men who patrol the highways say.

"Last year 10 out of 35 Texas turnpike accidents resulted from one car trying to climb up the rear end of another. . . .

"As drivers on turnpikes, expressways, thruways, or whattya-call-em . . . we just aren't used to having it so good."

Dr. R. N. Traxler
Research Engineer
Texas Transportation Institute

Research in

PART V: FACTORS AFFECTING

In the preceding articles of this series we have discussed briefly (1) the consistency of asphalt and how it can be measured accurately, (2) the susceptibility of asphalt to hardening by oxidation, (3) the variables that influence the amount of structure in an asphalt, and (4) the adhesiveness or bonding of asphalt to stone. (These articles appeared in the March, April, May, and June issues of "Texas Highways.")

There are a number of factors that may influence the life expectancy or serviceability of a bituminous pavement. Some are not concerned directly with the properties of the asphalt but to a certain degree each may contribute to the durability of the binder and, thus, of the entire road. We will start at the beginning of the highway construction procedure and mention some of the factors that affect the serviceability of the final product.

Foundation or Base

Inaccurate or inadequate evaluation of the soil structures through which the road is to be built and failure to correct weaknesses that exist can result in serious reduction of service characteristics of the finished road. For example, if the foundation is composed of a clay, which expands and contracts with gain and loss of water, deterioration of the traffic-bearing structure can be expected to occur. The most satisfactory asphaltic binder cannot be expected to withstand the disruptive forces exerted by such severe soil movements.

Poor drainage frequently contributes to the deterioration of a roadbed. In addition to causing expansion of certain kinds of clay, as mentioned above, presence of water weakens the bond between the asphalt and aggregate. Excessive moisture may also cause certain aggregates to disintegrate. Water entering from the subgrade can cause serious deterioration of the road even when the best aggregates and asphalts are used. In subfreezing weather the presence of water in the foundation or road can become a serious problem because of ice formation, especially if there is present an excessive amount of fines in the aggregate. It is conceded by most road builders that the entrance of moisture into the foundation and surface layers is one of the important factors adversely affecting the serviceability of a bituminous pavement.

Road Surface

Assuming that a suitable foundation has been prepared and adequate drainage assured, deterioration of a bituminous pavement must be related to the road surface, which is composed of a mixture of stone and asphalt. Logically, the required thickness of the bituminous surface will depend upon the weight and volume of traffic it is expected to carry. Satisfactory serviceability cannot be expected if the design and/or thickness of the bituminous mixture is not adequate to support the traffic. Under such conditions, failure cannot be attributed to unsatisfactory properties of the asphalt per se.

A common cause of weakness is the use of a bituminous mixture, which after compaction is so open and porous that it permits the entrance of air and water. This can result in hardening of the asphalt and weakening of the bond between the asphalt and stone. An open, porous pavement surface, which is susceptible to rapid deterioration, may be caused by insufficient asphalt to properly fill the voids in the aggregate and/or by inadequate compaction of the asphalt mixture. Poor compaction may result from allowing the hot mixture to cool before compaction is started. Or, the rollers used may be too light in weight for the layer of mixture. In some cases too few passes are made with a heavy roller. The type of roller used may, also, have an important bearing on the degree of compaction. If, after all precautions have been taken, a porous surface results it is advantageous to apply a light seal coat. The increased durability gained by such an application is sound economy.

Aggregate

Quality of the aggregate used in construction of a pavement has an important part in its durability in service. First of all, the stone must be properly graded to give a mixture of adequate strength. Next, it must be hard enough to resist degradation during handling and compaction of the mixture and by the forces applied in service. Further, the aggregate should not be susceptible to disintegration

Asphalt Quality Control

SERVICEABILITY OF A BITUMINOUS PAVEMENT

because of reaction with water or air. Presence of deleterious fines adhering to the stone surface is a most undesirable condition because it interferes with a good bond between the asphalt and aggregate.

Use of a stone which is capable of absorbing some of the low viscosity components of the asphalt may result in reduced serviceability because of excessive hardening of the binder and reduction of the film thickness. The absorptive effect occurs only with a porous stone and is likely to be most serious with a "gel-type" or poorly dispersed asphalt. Such a binder can loose a considerable amount of oil to a porous stone through capillary attraction. In a well-dispersed or "sol-type" asphalt the oil is not so free to migrate into the pores of the stone. There are indications that the chemical compositions of certain aggregates accelerate the oxidation and hardening of asphalt films, but little is known about the effects that occur at the interface between aggregate and asphalt. This is a challenging problem in the field of asphalt technology.

Asphalt

We now come to our basic theme, namely the effect of the asphaltic binder on the service characteristics of a bituminous pavement. The form in which the asphalt is used is important. The binder may be blended with the aggregate as (1) an asphaltic cement, which must be heated to yield a viscosity low enough to permit handling and mixing, (2) a cutback in which the asphalt is dissolved in a hydrocarbon solvent to obtain a low viscosity, and (3) an emulsion, which is a dispersion of asphalt in an aqueous solution to give a reduced viscosity at atmospheric temperatures. Each of these forms are attractive and valuable to the road builder under particular circumstances but he must use considerable judgment in his selection. Of the 15 million tons of paving asphalt used in the United States during 1959, slightly over 50 per cent was in the form of asphalt cement, about 40 per cent was some type of cutback, and the remainder, less than 10 per cent, was asphalt emulsion.

Consistencies of the asphalt cements commonly used in road building vary from 200 to 60 penetration (0.2 to 10 million poises) at 77°F. Selection of the most suitable consistency for a particular job sometimes poses a problem. The argument usually advanced for use of a soft binder is that an asphalt of low viscosity will yield a pavement of long serviceability because a greater period of time will be required for the bitumen to attain a hard, brittle, nonadhesive condition. This argument appears quite logical but there are certain factors which oppose its complete acceptance. Assuming all other variables (aggregate grading, etc.) are maintained constant, it is possible to incorporate more hard asphalt into a mixture and obtain satisfactory stability, than when a soft asphalt is used. Attainment of a given set of engineering flow properties, such as stability and cohesion, with a soft asphalt means use of a limited amount of asphalt spread through the mixture in the form of thinner films than are obtained with a harder binder. The thinner films will harden at a more rapid rate than will the thicker, more viscous ones, thereby reducing the advantage obtained by starting with an asphalt of lower viscosity. The use of larger amounts and thicker films (obtained by employing harder asphalts) naturally results in a paving mixture that is better protected from the deteriorating action of entering air and water. Another phenomenon that tends to result in the more rapid hardening of a soft asphalt, thereby offsetting its original advantage, is the greater absorption of oily components by porous aggregate. When an absorbent aggregate is used, some of the lighter components are removed even from a 60 penetration (10 million poise) asphalt, but the effect is more pronounced and occurs over a longer period of time when a 200 penetration (0.2 million poise) asphalt is used. Thus, the advantages frequently mentioned for the use of a low-viscosity asphaltic binder are to a considerable extent reduced by a number of factors not usually contemplated. Consistency of the asphalt should also be considered in relationship to climatic conditions. There seems to be general agreement that road building in tropical or semitropical climates requires use of a somewhat harder asphalt than should be used for road construction in temperate or subarctic regions.

A disadvantage attached to the use

of some types of cutbacks is the low viscosity of the asphalt present in the mixture. This means that the amount of asphalt incorporated into the pavement must be reduced to obtain the necessary stability. As mentioned above, the films of soft asphalt are thin and subject to rapid hardening. Because of the fluidity of the liquid in contact with the aggregate, extensive absorption may occur if a porous stone has to be used. These effects vary, naturally, with the grade of cutback and the kind of asphalt used in its manufacture. It may be pointed out here that medium-curing cutbacks (made with a soft asphalt) are most widely used, but the rapid-curing materials (containing somewhat harder asphalts) follow closely in tonnage consumed.

Asphalt emulsions for road building are usually prepared from soft asphalts (about 0.2 million poises at 77°F) and, thus, are subject to the factors influencing the behavior of the same consistency asphalts used in the form of cutbacks or cements. The use of asphalt emulsions and cutbacks in the construction of soil-stabilized roads also raises another problem. When the soil contains certain types of clay, *adsorptive* forces may enter the picture. In this situation the highly adsorptive mineral surface removes the harder components (asphaltenes) from the asphalt and leaves as a binder a softer material than was originally mixed with the soil.

For various reasons the road builder may use too little asphalt in the design of his mixture. This situation can develop through his attempt to attain a set of engineering characteristics that will assure satisfactory behavior under the anticipated traffic load. He may have been embarrassed in the past by building a road that shoved under traffic or exuded asphalt and became slippery during rainy weather because of too much asphalt for the aggregate used. The result of such an experience is a tendency to play safe and use too little rather than too much binder. Use of a low-viscosity asphalt will tend to accentuate this trouble. There is less risk involved in the use of a high viscosity binder. The road builder can, to some extent, escape the dilemma posed above by using an asphalt possessing a viscosity slightly above one million poises (below 90 penetration) because he can put more asphalt and thicker films into his mixture. He, thereby, obtains a more durable road because it is less subject to deterioration under service conditions. Use of a high-quality asphalt cannot entirely overcome the deteriorating effect resulting from the presence of even 0.5 per cent too little asphalt in the paving mixture.

Now that we have discussed some of the conditions responsible for a change in binder consistency, let us turn our attention to the asphalt itself. Road-building asphalts, all of which fall within present consumer specifications, can vary widely in composition and in behavior under service conditions. In recent years, advances have been made in procedures for evaluating asphalts in respect to their anticipated resistance to deterioration during construction and use in a highway. It has been shown in Part II of this series that different asphalts, meeting standard requirements of specific gravity, penetration, softening point, and ductility, may vary widely in their susceptibility to hardening when subjected to the effects of heat, oxygen, actinic light, and aging. What is the cause of this difference in behavior among various asphalts? The explanation most likely will be found in the colloidal characteristics of the bitumens, which in turn, are linked to their chemical composition. To obtain a long-lived pavement, an asphalt should be used which possesses the chemical composition required to give a well-dispersed system capable of resisting to the greatest degree the hardening and deteriorating influences encountered during construction and service. In addition to possessing low susceptibility to hardening by heat, oxygen, and sunlight and the development of limited internal structure upon aging, the binder must exhibit adequate adhesion for the aggregate. The strength of the bond between the binder and aggregate depends on the chemical composition of both the asphalt and the stone. Bonding strengths of paving asphalts for aggregates have been improved by the use of small amounts of adhesion additives.

It is evident that the failure of a bituminous pavement to give the ultimate in serviceability may be caused by any or all of a number of factors involving design and the quality of material. These may be operating as complimentary or conflicting effects. Although quality of the asphalt—especially in respect to its ability to resist hardening and loss of adhesiveness—is most pertinent, it is only one of many elements contributing to the service life of the bituminous pavement. The asphalt should not be made the whipping boy for all of the failures that occur. However, a vigorous and sincere effort should be made to supply the road builder with the best binder it is possible to manufacture.

Many different types of failure in bituminous pavement could be illustrated; only one has been selected for use here. The particular example is a hot-mix asphaltic concrete overlay on a portland cement concrete base. After about eighteen months of service, the surfacing material had eroded away in places. Figure 1 shows one of the eroded spots. The asphalt used met OA-90 specifications. A stock sample from storage at the plant possessed a penetration of 87 (1.2 million poises) at 77°F. Quality of the asphalt was about average in its resistance to hardening by heat and oxygen.

A few pounds of the surfacing material were removed from a location adjacent to the eroded area shown in Figure 1. Benzene was used to extract the bitumen from this sample and the asphalt was recovered from the benzene solution by the standard Abson recovery procedure. The asphalt obtained from the deteriorating surface

course had a penetration of 30 at 77°F. Thus, by this test it had hardened about threefold in the preparation and laying of the hot mixture and during eighteen months of service. Viscosity of the recovered asphalt was found to be 19 million as compared with 1.2 million poises for the original asphalt, or a 15.8 fold increase in hardness by this method for evaluating consistency. These values offer another example of the greater sensitivity and precision obtained by using viscosity for the measurement of consistency.

What were the causes for the failure of this surface and for the excessive hardening of the asphalt? The answer probably can be found among the following factors:

(1) The asphalt possessed somewhat inferior resistance to the action of heat, oxygen, and sunlight.

(2) The films of asphalt on the stone were overheated and oxidized during preparation of the mixture.

(3) Insufficient asphalt was used in the mixture.

(4) The mixture cooled on the road before compaction was started, resulting in an open, porous surface.

(5) Improper compaction techniques were used, resulting in a low-density surface.

(6) Inadequate compacting equipment was used.

(7) A poor grade of aggregate was employed.

From observation of the road it was apparent that the surface was open and had allowed air and moisture to enter, which accelerated the hardening of the asphalt and weakened or destroyed the bond between the aggregate and binder. The stone did not appear to be of high quality. A careful scrutiny of any road failure should bring to light one or more of the factors mentioned above as responsible for poor durability.

Summary

These short discussions concerning the properties of road-building asphalts began, in Part I, with a review of the methods used for evaluating their consistencies. It was shown, by recently obtained data, that consistency measurements expressed in absolute units of viscosity are more sensitive, discriminatory, and informative than the commonly used penetration test. An up-to-date microfilm viscometer for measuring the viscosity of thin films was illustrated and discussed.

Part II described procedures for evaluating the susceptibility of a paving asphalt to oxidation. The viscosity of an asphalt before and after heating films of various thicknesses in air at temperatures from 225° to 325°F were measured in the microfilm viscometer. It was shown that a group of commercially available OA-90 asphalts varied widely in their resistance to the hardening effect of heat and oxygen and presumably to their durability in the road. The thesis was advanced that the susceptibility to oxidation and hardening is dependent upon the chemical composition of the asphalt.

The causes for the development of structure in an asphalt were considered to reside in (1) source of the asphalt, (2) method of processing, (3) degree of processing, (4) effect of heat and oxygen, (5) effect of short wave lengths of sunlight, and (6) age hardening. Examples of each were shown in Part III. Evaluation of internal structure in asphalts by rheological (flow) measurements was described.

The practical importance of a good bond between the asphalt and aggregate was pointed out in Part IV. Available methods for evaluating adhesion were mentioned, and the difficulties encountered were stressed. An example of the type of data obtained by the Immersion-Compression method was given. The use of adhesion additives was cited and the recently developed cationic type of asphalt emulsion was discussed because of the good adhesion obtained with acidic types of stone.

Finally, in this current section, a brief review has been made of the numerous factors that influence the durability of a bituminous pavement. Poor design, low-quality aggregate, inferior handling of the materials during mixing and application to the road and, finally, the use of asphalts that are not sufficiently stable and resistant to hardening are the most important causes for failure.

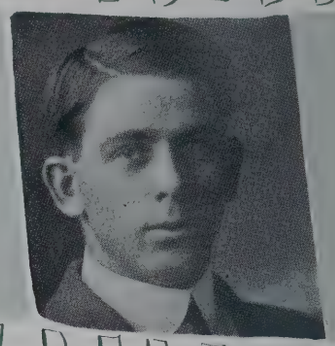
The purpose of this series of articles has been to present in the briefest possible form some of the latest advances in asphalt technology. The author will be happy if he has inspired the reader to a constructive train of thought concerning the problems involved in the construction of high-quality bituminous pavements.

Man has used asphalt for several thousand years, but only recently has he learned a little about its unique characteristics. The current investigations on asphalts and bituminous pavements at the Texas Transportation Institute are directed expressly to a fuller understanding of this adhesive material and to the practical problems encountered in the improvement of its quality for use in pavements.

Figure 1—Eroded spot in a hot-mix asphaltic overlay on a portland cement concrete base after eighteen months' service.

Harvey Deen

Gardener
Mechanical Genius
Top Expediter



"Harvey Deen, Engineer of Aid Projects, retires July 1." The nine words making up this statement of facts fail entirely to tell the actual story.

The severing of ties is always severe. And in the case of a man and his job, when both have grown together over a period of 39-plus years, it is hard to tell where one begins and the other ends.

So it is with Harvey Deen, Engineer of Aid Projects.

To attempt a word picture of a man as complex as Harvey Deen is a bold, and impossible, venture. Certain images, caught and retained during a brief interview, can be placed on paper to serve as single brush strokes in an over-all picture. Foremost feature of the man is his eyes—bright, alert, intelligent, and interested. The eyes of a man who can be stubborn if need be, but a man who accomplishes his aim.

A product of Austin schools and the University of Texas, Deen is married and has two daughters, Carolyn and Mildred. Carolyn, now Mrs. James Wier, works for Operations Division and is the mother of Deen's seven-month-old grandson. Mildred works for the State Comptroller in Austin.

Deen started his career with the Department on August 1, 1919, as a checker to review plans. From that time until June of this year, he has been continuously employed in a number of key positions with only one break in service—this a result of the stormy political seas which for a brief period flooded the Department back in the twenties.

In the interim between that August 1919 employment as a checker and retirement, Deen handled such projects as supervising the building of the Main Office in Austin. Before this could be undertaken, the Old Travis County Jail which stood on the site of the present Highway Building had to be torn down. Responsibility for this chore also fell to Deen.

Reminiscing about the days of wrecking the old jail, Deen recalls that they had trouble disposing of the tons of steel in the building. No one would buy it. To get rid of the steel, they were forced to use acetylene torches and cut up the steel, then deliver it to the junk man free.

"This was during the days of Prohibition, and there were 30 to 40 cases of good liquor in the jail which had been confiscated in bootlegging arrests," Deen relates. He worried about theft of the liquor, and mentioned it to those in charge of the old jail, but since it was locked behind bars, no one else was concerned for its safety. One morning they arrived at the jail site to find every bottle drained of the precious (at that time) liquid. Some ingenious thief had devised a method for lifting the bottle out of the case, pulling the cork, and pouring out the contents without touching the bottle with his hands.

Deen worked with C. W. Adams, architect, in design and construction of the Main Building. And after it was completed, in 1933, he was for ten years in charge of the building. Recalling the setup, Deen muses, "At that time, elevator operators were employees of the Board of Control, and there were many times when I operated the elevators."

If only one word could be used to describe Deen's thinking, that word would be "expedite." Within his own Aid Division, which handles about 600 construction vouchers per month, his expeditious methods are in operation everywhere. To save time, Deen was responsible for purchase of a special machine to type and prove vouchers. He developed a method, using a magnet, by which a typist could just stick paper-clipped pages against a board and it would hold there for typing. An intercommunication device which he designed and had built in 1934 is still in use in Aid Division.

This expeditiousness is not limited

That Deen was a dedicated ord. At the dinner honoring Liaison Committee, Assist J. C. Dingwall brought up th more than 39 years and ha cation. To justify the vaca *had* taken ten days off—to

to the division he headed at retirement. His additions to the Department are too numerous to list. He was responsible for purchase of our first blueprint machine—when the Department was housed in the basement of the Land Office Building. The machine paid for itself in six months. Later, Deen established Reproduction Section, on the sixth floor of present Main Building. He had purchased previously transits, levels, and calculators, and always a man with foresight, Deen saw the need for keeping these machines in good repair. To handle this, he set up a shop for instrument adjustment and repairs, and designed the collimator used in adjusting transits.

Deen's ability as an organizer was early recognized. In 1927 he was brought in to reorganize Aid Division. At one time in early highway days, Deen took over and supervised construction of defaulted road projects in Van Zandt and Harrison Counties.

Titles he has held include Superintendent Federal Aid, Superintendent Aid Projects, General Resident Engineer, Supervising Engineer, and finally, for the past seventeen years, Engineer of Aid Projects. During the past twenty years, Aid Division, under Deen's leadership, has processed close to $2 billion on contractors estimates. Largest voucher issued under Deen was for right of way—$1,057,500 in January of 1958. Largest construction voucher to date was made in March of 1959 to U.S. Steel for $598,530.51—a partial payment on the Corpus Christi Harbor Bridge project.

A man who avoids the limelight and abhors having his picture taken, Deen faced the camera on at least two occasions during his last week with the Department. The first time, he was honored at his final meeting as a member of the Joint AGC-THD Liaison Committee. At a dinner, Associated General Contractors members presented him with a routing machine, and fellow Highway Department committeemen gave him a sander. Deen's office feted him on his last day with a party and presented him with a hand jig saw.

The nature of the gifts he received are a clue to Deen's Number One hobby. A man of many interests, Deen stays busy every minute, spending a great part of his time at home involved in woodworking.

"I like to tinker with anything that runs," Deen offers. Friends speak of his mechanical genius. He has made many electrical devices and most of the furniture in his home. What he did not make, he refinished. In his home he has a tilt-top table made from walnut bannister rails taken from the old county jailer's house.

Deen is also a gardener and hunter, never missing a year deer and quail hunting. J. C. Dingwall, Assistant State Highway Engineer, relates a story of "the one that got away." It seems that last year he and Deen were quail hunting and Deen brought down a quail. He stuffed the quail into his hunting bag and he and Dingwall were on their way. Suddenly the bird zoomed upward and outward. Repeated shots by Deen and Dingwall failed to bring down the quail.

Concerning Deen's plans for the future, he has nothing definite in mind at present—except work. Already he has been busy redoing some apartments—part of family property. But first on his agenda was a trip with his wife to Mansfield, Louisiana.

Harvey Deen has retired, but the improvements, methods, and procedures which he introduced as an administrator will be with the Department for a long time to come. One policy—that established by Deen that each desk must be absolutely clear before any employee left for the day—he hopes will never be changed. It will probably never die out, because ingrained in each D-7 employee will be a tendency toward neatness and organization of work that no number of years will erase.

an is obvious from his rec-im by the Joint AGC-THD t State Highway Engineer fact that Deen had worked taken only ten days of va-n, Deen admitted that he et married.

"This is something I have really wanted; it makes my workshop complete," were Deen's remarks on receipt of a jig saw from Aid Division Employees.

Deen holds the unopened gift of the AGC half of the Joint Committee—a router—in this picture. Quipped Sam Huff, "It's not so much that we are losing a division head as that we are gaining a source to borrow tools from." Left to right are J. C. Dingwall, Sam Huff, Percy Bailey, Mrs. Deen, Deen, Horace Kerr, R. W. Dial, and Don B. Smith.

Huff gets some last-minute words of advice from Deen before stepping into the job long held by human-dynamo Deen.

The first service awards presentation ceremony was held at A & M College in 1946. Those employees with 25 or more years were present for the occasion. See if you can recognize, still employed by the Department, Deen, circled, Bessie Bergstrom, Erin Bradfield, Joe Gresham, E. W. Duval, and Cleve Kinney.

Other THD-AGC Committee members are, on either side of the Deens, T. S. Huff, Randle B. Alexander, Allen Keller, Sam Pinson, and Jed Robinson.

Presenting the gift of the Highway half of the Joint AGC-THD Liaison Committee, Alexander remarked that Deen had always been generous in lending his tools. "But we didn't allow this to influence our selection of a gift," he added. The group gave Deen a sander for use in his woodworking.

TIRE CHANGER ADAPTERS

Preventive Maintenance

A money-saving idea from the Dallas District

Here's news that should be of great interest not only to those ten or twelve districts that have purchased mechanical truck tire changers for their maintenance warehouses, but also for those which might do so in the future.

T. S. "Tommy" Reeves Jr., Senior Shop Foreman of the Dallas District, and mechanics in his shop crew have developed a simple two-piece adapter for their heavy-duty truck tire changers which enables them to mount and dismount small passenger and pick-up tires. Reeves reports that a shortage of necessary funds kept their district from buying separate passenger-type changers for the Maintenance Foremen; consequently, it was necessary to make the most of the equipment they had at hand.

The adapter consists of a 1/4-inch steel plate seven inches in diameter. There is a 2 1/2-inch center drilled out, and around this center, a 2 1/2-inch square collar three inches deep is welded. This collar is of 3/16-inch plate. Two 11/16-inch holes are drilled in the base plate on opposite sides to coincide with the bolt circle of the passenger and pick-up wheels. These two holes will accommodate 5/8-inch pins which go through them and the stud holes of the wheels to prevent the wheels from slipping around on the adapter base.

The adapter goes over the center post of the truck tire changer with the three-inch collar down and the flat base side up. The tire and wheel assembly are placed over the center post and brought to rest on the flat base. Next, the 5/8-inch stay pins are dropped into place and the regular bead-breaking shoe or dismounting handle of the truck-tire changer is put into place.

Reeves developed a revolving sleeve made of two-inch galvanized pipe 6 5/8 inches long which goes at the top of the changer center post. Welded into each end of the pipe are two-inch washers with 1 1/4-inch center holes, with the bottom or base washer recessed into the pipe 5/16 of an inch. This sleeve revolves around the top of the center post as a base for the mounting or dismounting tools as the operator works around the bead of the tire.

According to D-4, a number of dis-

Tommy Reeves displays the adapter base and sleeve, developed by him and his shop crew, which allows them to use their heavy-duty truck tire changer for mounting and dismounting small passenger and pick-up tires.

At left is a sleeve developed by Reeves which revolves around the top of the center post as a base for tools used in mounting or dismounting a tire as the operator works around the bead of the tire.

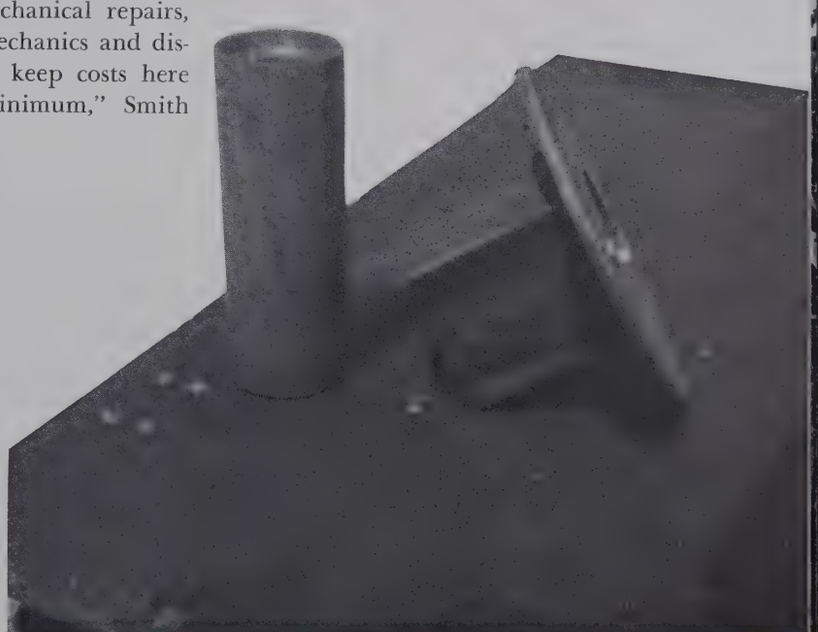
tricts have requested a combination truck-passenger tire changer on their requisitions, but manufacturers prefer to make and sell the individual truck and passenger changers instead of a combination one. This simple two-piece adapter should result in substantial savings for the districts.

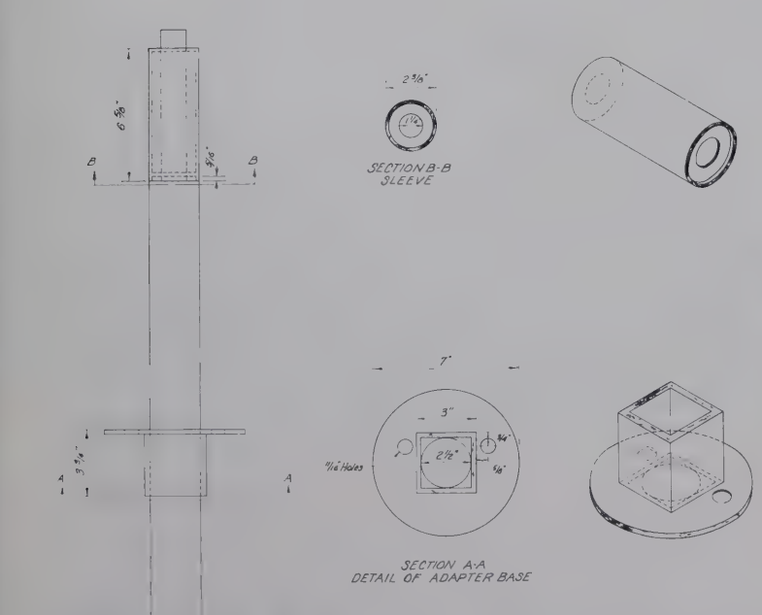
These adapter kits are manufactured in the Camp Hubbard Shops and are designed for the TTT type truck tire changers which most districts appear to have bought. Cost is approximately $10, and their use should eliminate the necessity of purchasing passenger type changers.

Melvin Smith, Senior Equipment Supervisor of the Dallas District, reports that spot checks now being made at unannounced intervals by him and his traveling mechanics have resulted in much improved equipment maintenance. Records of these checks are kept on field inspection form 1079 and compared with previous showings to determine improvement. Too, as fast as funds will permit, all maintenance warehouse service facilities are being improved.

"Our Maintenance Foremen are able to service all their own equipment except for mechanical repairs, and our traveling mechanics and district shop personnel keep costs here down to a bare minimum," Smith commented.

The small holes in the base have been drilled to coincide with the bolt circle of the passenger and pick-up wheels. Pins placed through these and the stud holes of the wheels prevent wheels from slipping around on the base.





TIRE CHANGER ADAPTERS

J. F. Farlow Jr., Design Engineer
District 2

Introduction

This paper covers the properties, uses, application, and future of epoxy resin adhesives in the construction and maintenance of concrete structures and pavements, and illustrates by photographs some actual applications in the field and test results of laboratory application.

The epoxies are one of the most recent of the plastics found in the construction field and from a resume of the properties which they offer, it would seem of benefit to take advantage of them.

They can be provided in liquid or paste form and are two component compounds, which means that no reaction takes place until the two parts are mixed.

They have outstanding and permanent adhesion to concrete.

They are compounds which have a practically negligible amount of shrinkage.

They are thermosetting, which means that the curing process is irreversible and permanent.

And they are volatile free, which indicates that there is no physical or chemical property loss due to the release of one of the constituents.

History

Epoxy resin is a liquid polymer, which includes it in the plastics family. As has already been mentioned, most epoxy resins are two component compounds—a resin-base mixture and a catalyst or hardener.

They are formulated for any application method desired, either by trowel, brush, or spray.

The base resins for epoxies are polyethers, derived from the petroleum and coal industries. While there are any number of manufacturers of base resin, the largest sources are from the Ciba-Swiss Company, Shell Petroleum Corporation, and the Bakelite Corporation.

The patents to the catalysts or accelerators are held by many of the larger chemical companies in the United States and Switzerland. When the catalyst—an amine or polyamide —is added to the base resin, which is a polyether, there results a molecular combination of the two materials which forms a 100 per cent solid liquid polymer.

In addition to the properties already mentioned, the epoxies are designed to have an important degree of flexibility, allowing them to withstand shrinkage strains resulting from concrete curing.

Application

The California Highway Department first used epoxy resins for highway maintenance purposes in January of 1955 in connection with a precast concrete traffic divider fastened to the road surface by steel dowels. Dowels remaining on the highway became a traffic hazard when a bar was knocked loose or shattered by impact. They investigated the use of epoxy resin adhesives and found them to have exceptional bond to clean concrete and used the adhesive to fasten traffic dividers to the pavement, eliminating the steel dowel.

This application opened a new field for the formulators. They went to work to develop epoxies especially suited for bonding old concrete to old concrete, new concrete to old concrete, and compounds which would even set up under water.

Today epoxies are being used to bond extruded curbing to pavement, patch spalled surfaces, bond traffic buttons to the roadway surface, and bond steel dowels into concrete.

Results of testing have been impressive. Epoxies have proven versatile

***This report was written by Jack F. Farlow for presentation at the Thirty-fourth Highway Short Course and is released for information purposes.**

and easy to use. Epoxy adhesives for concrete bonding have been specially developed to insure high flexural and shear strengths, along with resistance to wear and corrosion. The effective strength of the adhesive has been found to be the actual strength of the concrete, since the strength of the adhesive and its bond are substantially higher than the cohesive strength of the concrete mass.

In addition to being resistant to water, gasoline, jet fuels, lubricating oils, solvents, and deicing salts, epoxies can withstand freeze-thaw cycles and temperature extremes from –70° F. to well over 350° F.

The epoxies have a short pot life—once they are mixed they must be applied to the intended surface in 30 minutes to an hour, depending on the temperature. After application they remain tacky from one to three hours, again dependent upon the temperature. Most of the adhesives will develop their strength in from 6 to 24 hours. Setting time can be accelerated by heating if practical.

The Fort Worth District has experimented with and tested several manufacturer's products. Nearly all of the formulations vary in the ratio of catalyst to base, viscosity of the mix, pot life, and setting time. Nearly all of the catalysts will cause dermatitis if proper care is not taken, so for that reason gloves are usually worn during mixing and application. The mix is toxic and should be applied under conditions of good ventilation.

Figure 1—The beam is centered in the beam machine and rebroken.

One manufacturer provides kits with preweighed base resin and catalyst, with the resin container only partially filled so that it can be used for mixing. This eliminates weighing and measuring. In addition, the resin is colored blue, the catalyst colored yellow, and the directions state that the mixing is complete when the mix is a uniform green color. This simplification allows adequate mixing of the components, an important aspect in epoxy technology.

Where a full kit would not be used in one application it has been the District's practice to have the District Laboratory weigh out the prescribed amounts of base and catalyst in cardboard containers which are then mixed in the field. There is also an economical aspect to be considered—

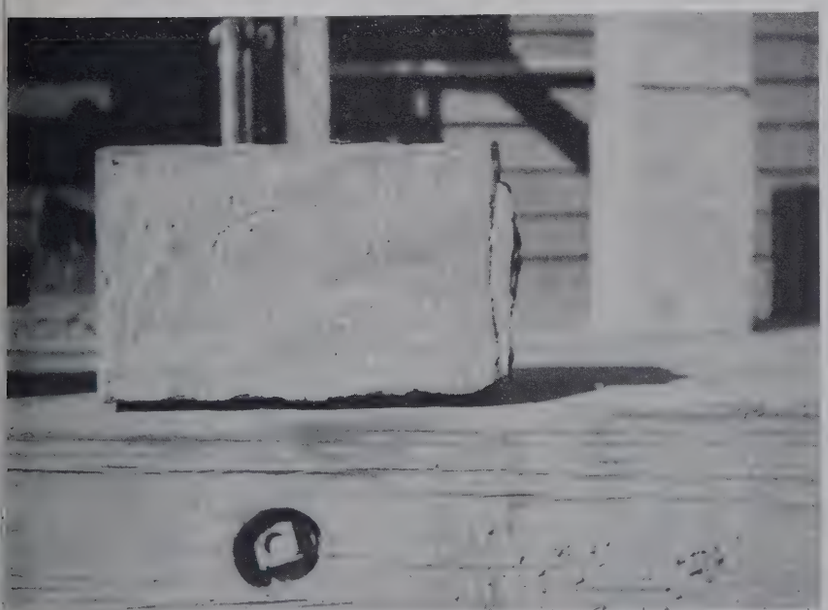


Figure 2—The resultant break shows that the beam broke in a new location and did not break the bond.

Figure 3—The end view shows broken aggregate in both faces of the beam, indicating superior bond.

epoxies purchased in larger quantities are about half the unit price of the small kits.

Photographs show procedures by which flexural strength of the adhesive was tested.

In the first test conducted, a Class A Concrete beam was made and its seven-day flexural strength recorded. The broken ends were then prepared by brushing with a steel brush and removing all dust and loosened particles with air, after which the epoxy resin adhesive was applied to both surfaces. The beam was stacked and allowed to set from 24 to 48 hours in room temperature. The reconstructed beam was centered in the machine and rebroken as shown in Figure 1.

Figure 4—An end view of the beam shows mortar pulled from the face of the beam, indicating superiority of the adhesive, but lack of aggregate interlock results in low flexural strength.

The resultant failure was not at the previous break, but broke along a new face which can be seen in the side and end views of the beam (see Figures 2 and 3).

All properly prepared beams tested in this manner gave an equivalent flexural strength to that of the first break.

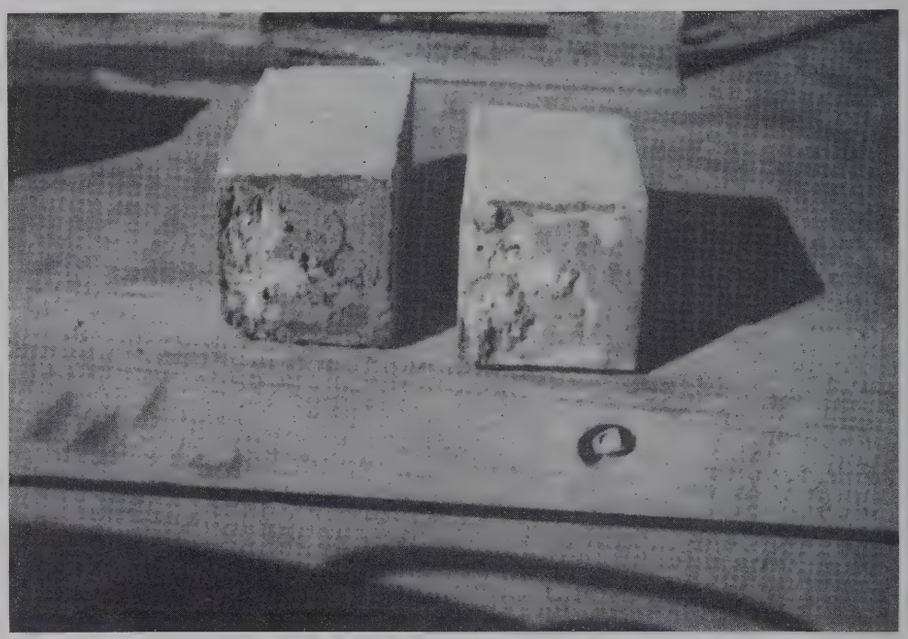
Another application of the resin for a flexural strength test was investigated by bonding the smooth ends of a previously broken beam. The results varied with the class of concrete used to make the beam, and the strength was found to be a function of the mortar since absence of aggregate interlock failed to transfer the load into the beam. Figure 4 shows the test and resultant break in which some mortar was pulled off of one of the two faces, indicating the bonding strength of the adhesive. To achieve the required strength with this type test the beam ends would have to be roughened to expose aggregate particles at least 1/32 to 1/16 inch in size.

A third test for flexural strength of the adhesive and adaptability to field application was to prepare and paint the broken end of a half beam, place it in a beam box, and pour new concrete against the old. These results were satisfying, since the new concrete at seven days would fail in flexure, indicating a substantially strong bond of new concrete to old.

The thickness of the material applied need only be approximately 5 to 10 mils. The coverage that can be expected for a 10-mil film using a brushable compound is approximately 120 square feet per gallon.

The condition of the surface to which epoxy resin is to be applied must be one that is dust free, dry, and free from oil and traffic grime. Ordinarily, a heavily worn or weathered pavement with exposed aggregate particles at least 1/32 of an inch in size is suitable for application. It may be necessary to sandblast extremely dirty or oily pavements, and some of the formulators call for an acid etch of dirty pavements using a 10 per cent hydrochloric acid solution. Vigorous brooming and flushing with water should follow an acid etch to remove dislodged particles. It is then essential that the surface be allowed to dry before application of the adhesive.

One of the first applications of epoxy resin adhesive in District 2 in the field was completed recently, and the material was used to bond an extruded concrete curb to an existing concrete pavement. A portion of I.H. 20, recently opened to traffic, had a ramp with a rather wide throat which possibly could allow two vehicles to enter the main lanes. The desire was to reduce the width at the throat to fourteen feet. The new concrete pavement was deemed to have a surface texture coarse enough and clean enough to eliminate any need for any excessive etching and cleaning before application of the adhesive. The surface was brushed and air was used to remove loosened particles and dust. Two different epoxy resin products were used; a thin brushable liquid to bond one section of the curb, and a paste which had to be troweled on to bond the remainder of the curb. Figure 5 shows the adhesive being spread immediately ahead of the extruding machine. This operation made it possible to match the existing curbs on this project and eliminated the expensive doweling and grouting process to obtain bond.



The approximate cost of the first material mentioned for bonding an eight-inch base concrete curb was 12 cents per linear foot. Figures 6 and 7 show the extruding machine in operation and a finished view of the extruded curbs.

The District traffic engineering de-

partment recently bonded four-inch ceramic traffic markers to concrete pavement with excellent results. They were used to delineate left-turn movements at a complicated signalized interchange. Since traffic needed to be released in the area as soon as possible, the markers were heated by blowtorch to speed up curing of the adhesive. In about four hours, sufficient set was obtained to allow traffic over the area.

Patching of potholes in concrete pavement has long been a nuisance to maintenance crews. Not only is there considerable hazard involved during the patching operation, but the fact is that very few patch jobs ever stick and the same potholes reappear. Figures 8 through 12 show a patching operation using epoxy resin as an adhesive to bond a new concrete patch to existing concrete pavement.

The expansion joint was first cleaned out, and a section of preformed expansion-joint material was cut to size. Figure 8 shows a typical pothole as it appeared before the patching operation began.

Expansion shields were installed at four points around the patched area. These served as anchors for a cover plate placed over the patch to allow traffic to flow while the concrete set. The hole was then brushed with a wire brush and blown out with air to remove all dirt and loose materials (see Figure 9). Sandblasting of the old concrete is probably a better means for exposing the aggregate and getting rid of accumulated dirt and trash. The epoxy resin is mixed and applied by brush to the entire surface of the pothole, as shown in Figure 10.

Portland cement concrete is troweled in and feather-edged out on all sides (Figure 11). (In this case it was necessary to patch on both sides of the expansion joint material.) Figure 12 shows a ⅜-inch steel plate bolted down over the patch. The plate was removed seven days after the concrete had set. Traffic appeared to ride over the plates with no hesitation, eliminating the need to barricade and flare the patches until they cured.

Figure 5—The resin is applied immediately ahead of the extruding machine.

Figure 6—View of the extruding machine as concrete curb is laid over the adhesive.

Figure 7—Finished view of the epoxy resin adhered concrete curb.

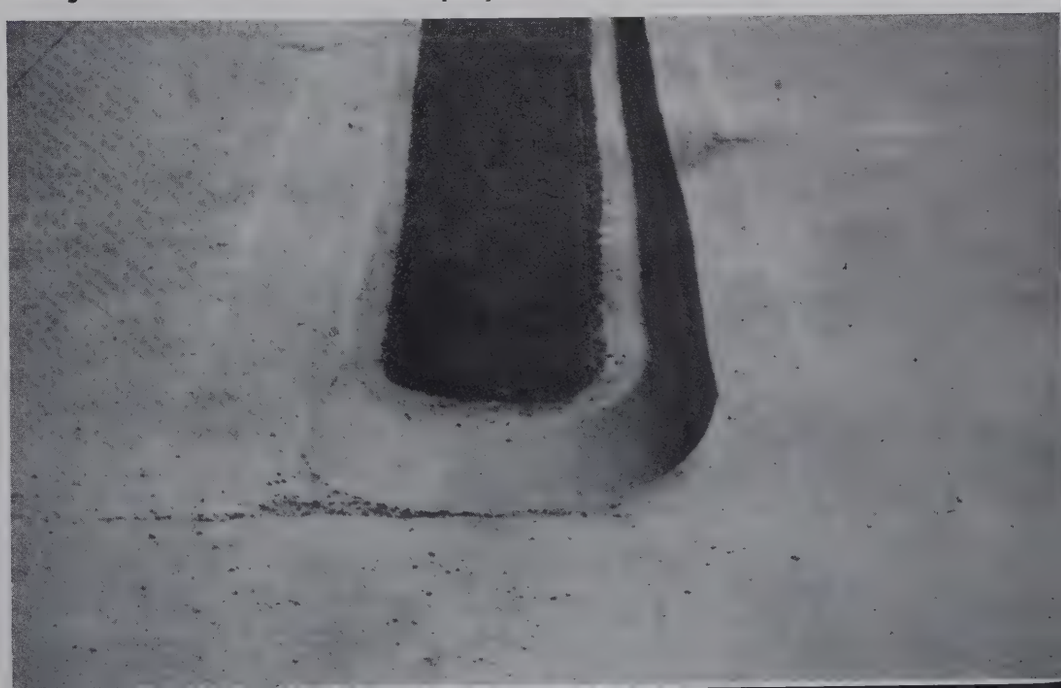


Figure 8—View of the pothole before cleaning operation.

Figure 9—View of the cleaned pothole and new expansion joint material placed in the joint.

Figure 10 — Application of epoxy resin adhesive complete.

Figure 11—Concrete placed in the pothole and feather-edged out onto pavement.

Figure 12—A cover plate is used to protect patch until concrete is cured.

Good bonding material is also needed where overlays of large areas are needed. Figure 13 shows the spalling of a bridge deck due to the closeness of the reinforcing steel to the surface. Sandblasting of the surface would be necessary to prepare it for the adhesive, and in this case it would be better to spray the resin on the surface. The approximate cost of the adhesive for a job of this nature would be from 13 to 25 cents a square foot for a 10 mil thickness. This spalled surface would require a varying thickness of a high early-strength concrete mix to resurface the spalled area, using the epoxy resin to bond it to the old surface.

Freezing of expansion joints on slab structures frequently causes large chunks of the abutment caps to spall off, leaving steel exposed. In Figure 14 the break has become a drain, causing straining of the cap and riprap slope.

The repair of this cap was the same as the repair of a pothole in concrete pavement, but due to the fact that the face was vertical, it was done by guniting the patch back to its original face, with the epoxy resin as the bond to the old concrete. The repair operation and finished patch are shown in Figures 15 and 16.

This report covers but a few of the everyday practical applications of this wonder adhesive in the maintenance of concrete structures and pavements.

This District is investigating the feasibility of using an epoxy resin traffic stripe in lieu of the painted traffic stripe. Information indicates that it has been used successfully in California, and also in some of the northeastern states. Test stripes of the material are planned in District 2, on both asphaltic surfaces and concrete surfaces. These will be observed for wear, visibility, and adherence to surface.

Dependent upon the volume of traffic and the surface condition, painted stripes on freeways in this District last for only about six months. The hazard alone to a striping crew cannot be measured in dollars and cents, but if it is found that an epoxy resin strip can be applied and expected to last from two to four years or even more, then the first costs of preparing the surface for an epoxy resin stripe and the cost of the equipment and material will probably be of little consequence.

This brings to mind another field which is developing along with the use of two component epoxy resins. Pumping units are being designed to accurately pump, meter, and mix the appropriate quantities of base resin and catalyst in a mixing head at a spray nozzle. As stated earlier, the pot life of a mixed epoxy resin is relatively short, dependent upon the temperature. For this reason, it would not be feasible to mix the necessary quantity required for a mile of center stripe and hope to get it all sprayed on before it sets up. These two component pumps have eliminated this problem by doing all the mixing in a small mixing head at the nozzle of the spray, and are also able to meter the required amounts of resin and catalyst in the right proportions. These units are easily adapted to either 5-gallon or 55-gallon containers, are easy to clean, and provide for a minimum of waste since only a small quantity of material is mixed in the mixing head.

Epoxies with abrasive additives have been applied to offer skid resistance to roads and pavements which have become worn and polished by traffic. It has been understood that the Turnpike Authority plans to put a surface coat of an epoxy resin adhesive, along with an abrasive aggregate, at their toll booths where there is frequent starting and stopping.

In the northeastern states where deicing operations subject concrete pavements to rapid deterioration, epoxies are being used as seal coats which are highly resistant to deicing salts and also have an outstanding resistance to freeze-thaw cycles.

Some epoxy overlays have had traffic put back on them after only four to six hours curing time.

The coverage for a 1/16-inch overlay is approximately one pound per square yard, or only 20 cents per square foot. This does not include the price for an abrasive aggregate which is broadcast over the adhesive for a nonskid surface.

The epoxies can be colored by adding pigment to the mix. Colored pavement areas might be used to delineate acceleration lanes or turning roadways from the main lanes and at the same time add skid resistance, eliminating deleterious effects of deicing salt.

Airports and air bases have used the

Figure 13—Spalling of the bridge deck was due to closeness of reinforcing steel to the surface. An overlay of concrete can be bonded to the existing surface with epoxy resin.

Figure 14—Close-up view of the popped-off concrete.

patch of tremendous strength and bond if an applicable situation occurs.

Closure

Epoxies are certain to become a widely used product in the highway field. They are impressive and thought-provoking when one is exposed to their properties. It is hoped that a more comprehensive study of the product and its application is forthcoming from this introduction and, as progress is made in its uses, it is hoped that new information can be passed on to enable all highway engineers to take advantage of new procedures as they develop.

Figure 15—Gunite application.

epoxy surfacing to protect asphaltic and concrete runways and pads from the deteriorating effects of jet fuels and oils and, at the same time, give a wearing surface to the coated areas.

A mixture of any epoxy resin and aggregate can produce a quick-set

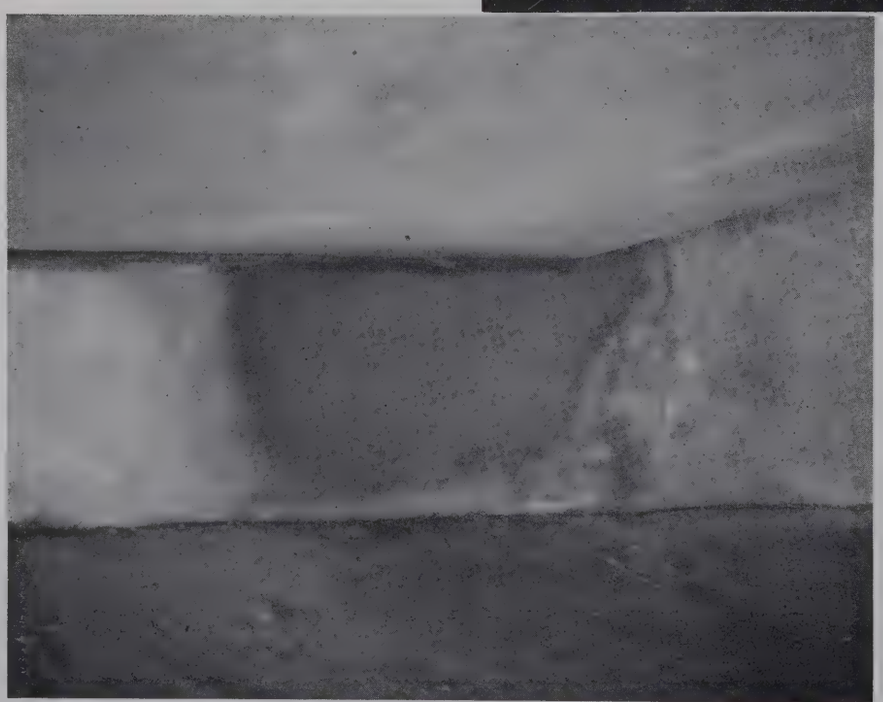


Figure 16—Finished view of the patch.

FIRST - AID pays big dividends

Garvin D. Chastain Jr.
Associate Right of Way Agent
District 2

Monday, November 30, 1959, seemed to be one of the longest school days ever endured by excited Clifford Wayne Burdett, energetic nine-year-old son of Mr. and Mrs. C. C. Burdett, 1220 Louise Street, Fort Worth, Texas. The youngster was anxious to get home and survey the progress made that day on the new highway under construction right by his house.

The highway contractor had recently moved in his equipment, and work was beginning on new Spur Highway 303, a multilane traffic artery that was to extend Rosedale Street in Fort Worth east through the Handley section to Arlington.

A portion of the right of way for this new highway, which was to pass within 100 feet of Clifford Wayne's house, had been purchased from the Burdett family; and now the waiting period was over, and construction was beginning.

The final bell dismissing classes for the day had hardly finished ringing before the boy was at home. For a panoramic view of the whole construction operation, he seated himself in a large oak tree on a limb about 30 feet above the ground. From this vantage point could be seen huge trucks, tractors, rooters, maintainers, bulldozers, carry-all scrapers, pneumatic compactors, and all types of earth-moving giants that would entrance a curious boy and make him forget his precarious position high above the ground.

From his position he could also get a good view of James R. Thompson, Senior Inspector, Texas Highway Department, working with the contractor's men to assist them in doing the construction precisely according to plan.

Suddenly Inspector Thompson's attention was attracted by the sound of snapping tree limbs, and he wheeled around just in time to see the youth falling to the ground.

Racing to the scene, Thompson found a small crowd beginning to gather and sensing the seriousness of the boy's injuries commanded, "Don't anyone touch him, I know exactly what to do." The knowledge of "exactly what to do" had been gained by Thompson through training received in The American National Red Cross Advanced Course of Instruction in First Aid to the Injured, sponsored by the Texas Highway Department.

By careful examination Thompson determined the extent of the injuries —a broken arm, broken leg, and profuse bleeding from multiple cuts, scratches, abrasions, and puncture wounds. He immediately set about to stop the serious bleeding, immobilize the fractured bone ends, keep the patient warm, and take other precautions to prevent or control shock, keep the injured boy lying down, calm, and as comfortable as possible until an ambulance could arrive.

The greatest problem Thompson experienced was keeping the boy calm in the presence of his near-hysterical mother. This he accomplished by keeping the mother as busy as possible in the house and away from the injured youth. She brought a pillow, blanket, gauze, materials for fashioning a crude splint to immobilize the broken fragments of bone, and phoned for a doctor and ambulance.

Upon examining Clifford Wayne in the emergency room at St. Joseph's Hospital in Fort Worth, Dr. Clayton praised the remarkable first-aid job that had been performed "by someone who had been well trained in first aid and surely was an artist in what he did." The doctor stated that the boy had received as good care as he himself could have administered under the conditions at the scene of the accident, and doubts not at all that this masterly first-aid treatment had a great deal to do with the child's rapid recovery. As of this writing, the boy's arm has completely healed, and a slight limp which is rapidly vanishing is his only reminder of the terrible accident.

Thompson modestly minimizes his part in helping to return this boy to good health by saying that he only did what anyone properly trained would have done under the same circumstances.

Mr. and Mrs. Burdett are much more lavish with their praise of the officials of the Highway Department, whose well-planned administration and commendable foresight make this training available to their employees, and they are especially thankful and grateful that Thompson, without one second's hesitation was ready, willing, and able to put this training to use by taking control and mastering this critical situation when his help was so desperately needed.

TRAINING in public relations

Young Clifford Wayne sat on a limb, indicated by arrow, above the tree ladder enjoying activities until the limb snapped. Then he found himself the center of all activity instead of an onlooker.

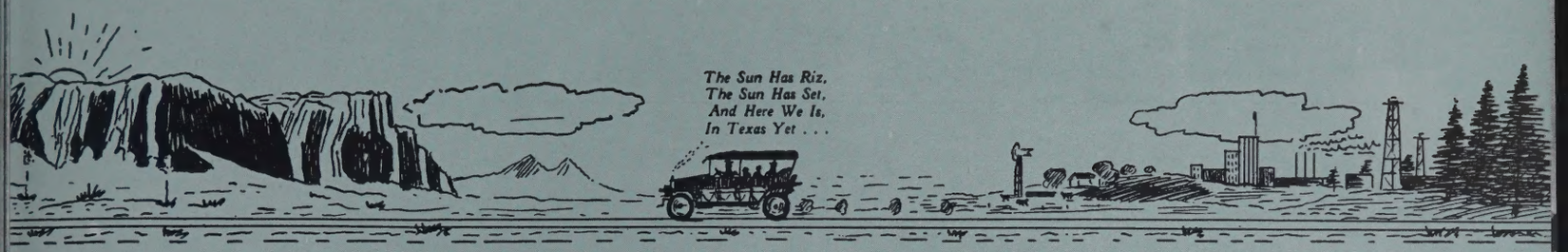
In Austin the plan was presented to interested government agencies at a luncheon May 17. Pictured are Highway Patrol Captain E. K. Browning; District Engineer Ed Bluestein; Mayor Tom Miller of Austin; AGC President L. P. Gilvin; Dr. Joe R. Humphrey, Administrative Officer of the State Defense and Disaster Agency; Colonel Homer Garrison Jr., Director of the Department of Public Safety; Travis County Judge Tom E. Johnson; Assistant State Highway Engineer J. C. Dingwall; and AGC Vice-President Allen Keller.

Operation Bulldozer

A plan whereby all contractors of America would bring their equipment and skilled personnel to the aid of disaster-stricken communities—or the nation—has been developed by the Associated General Contractors of America.

Through this plan, known as Operation Bulldozer, a list of all equipment and personnel available in time of crisis would be on file at a specified central organization in each area of the country. This equipment and personnel would be called into action after normal means of disaster relief and control proved inadequate.

Approved by civil defense and government officials, Operation Bulldozer is designed for use by AGC's 124 chapters and branches, but will include all interested contractors whether AGC members or not.



OVER THE HIGHWAYS

Comments . . . from the Traveling Public

On our way back from a trip to Mexico recently we had the pleasure of driving along your beautiful highways. Unfortunately we had a flat tire. Something we picked up in Mexico, no doubt. In less than five minutes one of your men from the Highway Department had stopped and was in the process of changing the tire for us. We were very grateful and offered to pay him for his trouble but he very politely refused.

No doubt this is not unusual in Texas as everyone seemed very friendly but it has been a long time since we have enjoyed such courtesy. I wish I had asked for his name. This happened on Highway 81 between Georgetown and Belton on May 23.

We will be looking forward to visiting Texas soon again.

Mr. and Mrs. Edward Elstner
Chicago, Illinois

We enjoyed spending the night at the Browning Roadside Park between Post and Snyder. We appreciate your provision of these conveniences. We also appreciate the cleanliness.

K. W. England Family
Round Rock, Texas

We, the people of Castro County, express our deep appreciation of the prompt and willing assistance given by your organization during the time of emergency in our recent tornado disaster.

We sincerely hope that we will never need to return this fine service, but should the need ever arise, please know that we are ready and anxious to assist in any way that we can.

Raymond E. Wilson
County Judge
Castro County, Texas

◆ *The above was directed to the Swisher County maintenance forces of District 5. The men from Tulia were in Dimmitt that night at a TPEA meeting and fell right in with the Castro County maintenance forces in rendering aid to the people of Sunnyside throughout the night of the tornado.*

We liked Texas a lot. You have wonderful highways with wide shoulders. Liked the scenery and hospitality of the people, too.

Lawton, Oklahoma

I am the mother of a seven and a half year old boy who has, during three years of serious illness and fourteen operations, become a "Texas Worshipper." This has come about mainly through television, which played an important part of his months of convalescence. In fact, we all call him "Tex."

His father and I were wondering if you could send us some printed travel folders, etc., on your wonderful state. We know Richard would be delighted. He is trying to save up for a "real Texas Cowboy" outfit.

His illness started when he was four and one-half years old and a local bully shot him in his ear with an air rifle. After many operations he is now a fine, healthy boy, and, thank God, even his hearing was saved by a wonderful surgeon.

We get many of the New York T.V. shows here and all the taped U.S. shows. Richard always compares the westerns with the comment—"If he came from Texas—," or "if that was in Texas it wouldn't have happened thusly." For many months he wouldn't eat, till one day I told him that Texans ate huge meals. It worked!

We hope, someday, to bring him to visit your state, when we recover from the expenses of his illness. Till then, the Encyclopedia Britannica, etc., will have to do.

My sincere appreciation for any consideration you may be able to give my letter.

Gladys I. Garon, R.N.
7221 Dunver Crescent
Crawford Park
Verdun, P.O., Canada

◆ *Richard will get all the literature we have to offer, and he'll have the honor of receiving the first copy off the presses of the new Texas Travel Brochure. If anyone else has something to send, Texas style, Richard would probably love it.*

To and From Our Readers

Bundy, left, and Matlock, right, share the honors.

Farland Bundy and Charles Matlock of Bridge Division, Austin, already loaded with prizes and awards for design of the Buffalo Bayou Twin Bridges in Houston, have come up with another one. This time it is the A. F. Davis Silver Medal from the American Welding Society for authoring "the paper which has contributed the most to the progress of welding in the field of structural design for 1959."

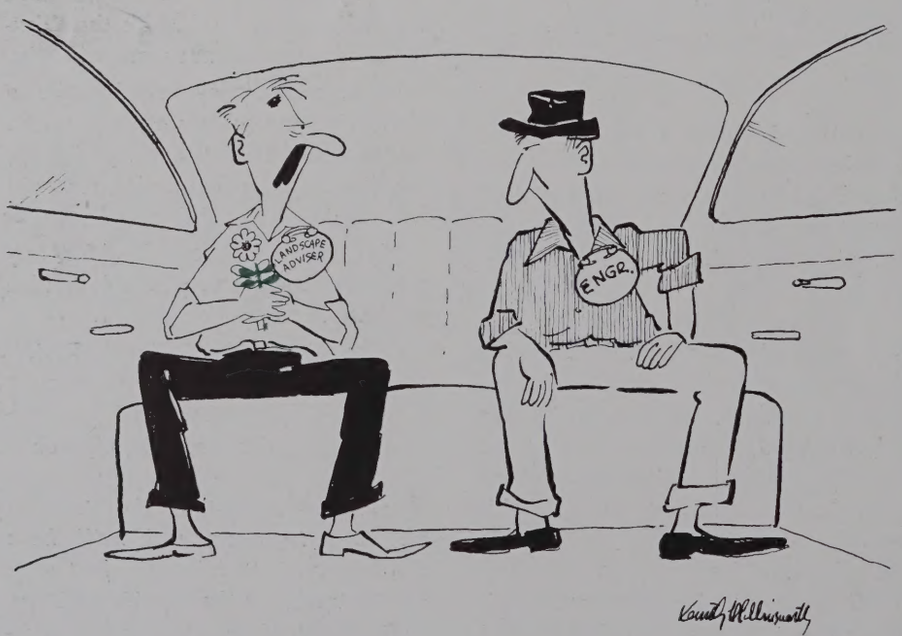
E. G. Franke of Uvalde Rock Asphalt has written in his suggestion that the new "Green Book" be blue, and enclosed a sample of his suggested color.

About Our Pictures . . .

The elevated section of expressway pictured on the cover is a part of Interstate Highway 20 in Fort Worth, and leads to the four-level interchange known as the Pretzel. (Top right.) Finished in March at a cost of $1.8 million, the elevated section completed the expressway through downtown Fort Worth.

The desert-and-mountain part of Texas pictured inside the front cover is on U.S. 80 about fifteen miles west of Van Horn.

The rolling, green topography pictured inside the back cover is found more to the center of the state. Flowers and shrubs line the sides of State Highway 71 fifteen miles west of Austin.

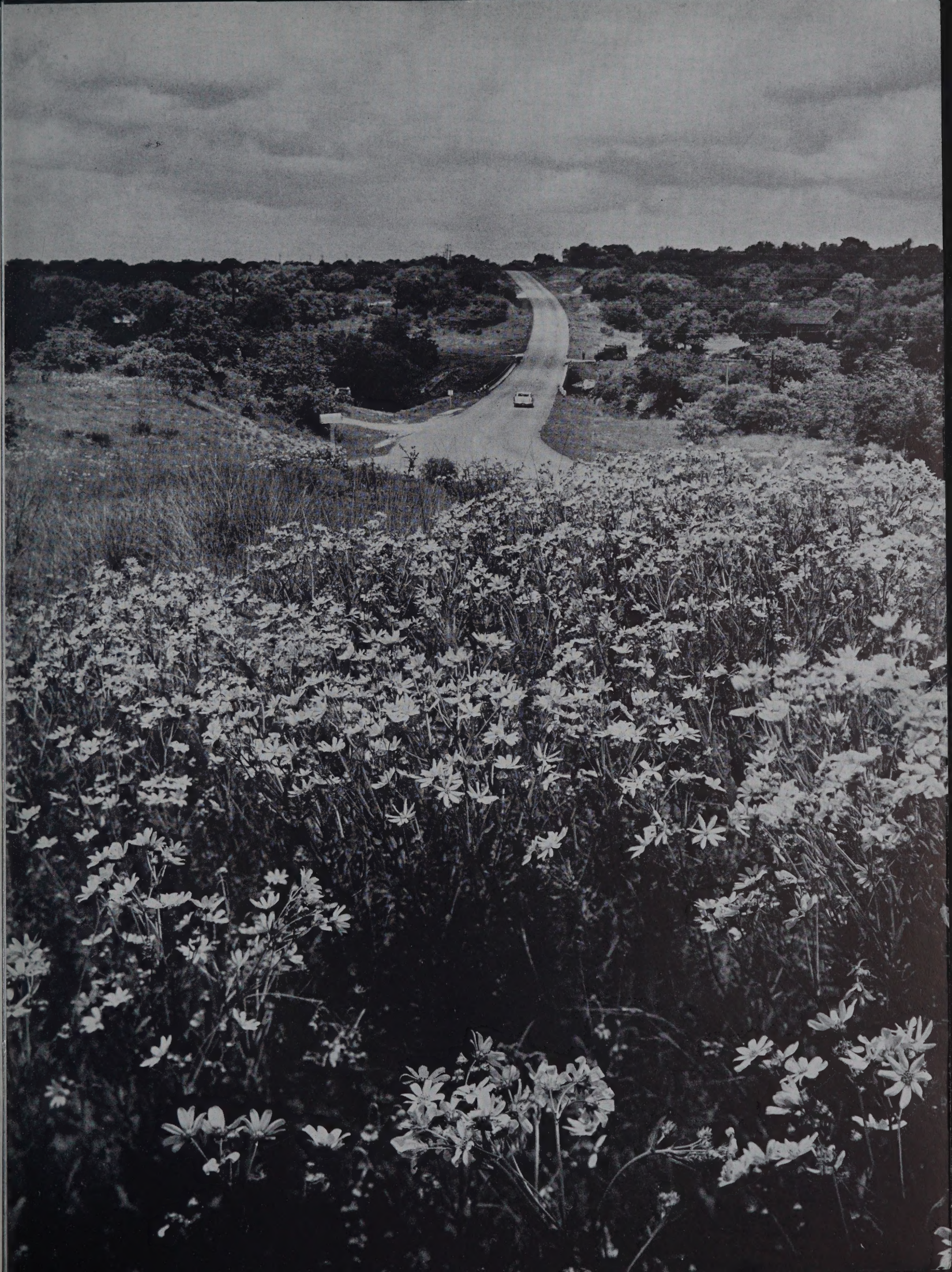


"SUPPOSE I TOLD YOU I THOUGHT YOUR SLIDE RULE WAS SILLY!"

TEXAS HIGHWAY COMMISSION

HERBERT C. PETRY JR.	**Chairman**
CHARLES F. HAWN	**Member**
HAL WOODWARD	**Member**
D. C. GREER	**State Highway Engineer**

Texas Highways

TEXAS HIGHWAYS, official journal of the Texas Highway Department, is published in the interest of highway development in Texas and for departmental education in the improvement of construction, maintenance, and operation.

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